PROCEEDINGS

OF THE

CALIFORNIA ACADEMY OF SCIENCES

(Fourth Series)

MAY 7, 2009 ★ VOLUME 60 ★ NUMBERS 1–9

CALIFORNIA
ACADEMY OF
SCIENCES

Copyright © 2009 by the California Academy of Sciences
All rights reserved. No part of this publication may be reproduced or transmitted in any form or by any means, electronic or mechanical, including photocopying, recording, or any information storage or retrieval system, without permission in writing from the publisher.

SCIENTIFIC PUBLICATIONS

Alan E. Leviton, Ph.D., *Editor*
Hallie Brignall, M.A., *Managing Editor*
Gary C. Williams, Ph.D., *Associate Editor*
Michael T. Ghiselin, Ph.D., *Associate Editor*
Michele L. Aldrich, Ph.D., *Consulting Editor*

COVER IMAGE

Holotype worker of *Apis* (*Cascapis*) *nearctica* sp. nov.
(CAS #236) as preserved.

See: Engel, Hinojosa-Diaz, and Rasnitsyn, A Honey Bee from the Miocene of Nevada (this issue) for details.

ISSN 0068–547X

The Proceedings of the California Academy of Sciences is an international journal that accepts manuscripts for publication in the Natural Sciences and selected areas in the Earth Sciences, such as biostratigraphy, regional and global tectonics as they relate to biogeography, and paleoclimatology, and topics in astrobiology, anthropology, as well as the history of science as they relate to institutions of natural history, to individuals, and to activities, such as expeditions and explorations, in the natural sciences.

All manuscripts submitted for publication in any of the Academy's scientific publication series (*Proceedings*, *Occasional Papers*, *Memoirs*) are subject to peer review. Peer review includes both internal and external review, internal review by at least one Academy scientist whose interests parallel those of the submission, and external review, ordinarily by two individuals who are recognized scholars in the field.

Manuscripts accepted for publication are subject to page charges; charges may be waived on a case-by-case basis.

Published by the California Academy of Sciences
55 Music Concourse Drive, Golden Gate Park,
San Francisco, California 94118 U.S.A.

Printed in the United States of America by
Allen Press Inc., Lawrence, Kansas 66044

PROCEEDINGS OF THE CALIFORNIA ACADEMY OF SCIENCES

Series 4, Volume 60, No. 1, pp. 1–18, 8 figs. May 7, 2009

Synopsis of *Dicliptera* (Acanthaceae) in the Nueva Galicia Region of Western Mexico with a New Species, *D. novogaliciana*

Thomas F. Daniel

Department of Botany, California Academy of Sciences, 55 Music Concourse Drive, Golden Gate Park, San Francisco, CA 94118 U.S.A.; Email: tdaniel@calacademy.org

This account of *Dicliptera* in the Nueva Galicia region of western Mexico includes an introduction to the genus, a key to and descriptions of the eight species known from the region, distributional and ecologic data for each taxon, and illustrations of most taxa. A new species, *D. novogaliciana*, is described and is endemic to western Nueva Galicia. Two names, *D. nervata* and *D. pringlei*, are lectotypified. The eight species treated are: *D. haenkeana*, *D. inaequalis*, *D. membranacea*, *D. nervata*, *D. novogaliciana*, *D. peduncularis*, *D. resupinata*, and *D. thlaspioides*.

Esta cuenta de *Dicliptera* en la región de Nueva Galicia de México occidental incluye una introducción al género, una clave a y las descripciones de las ocho especies sabidas de la región, los datos distribucionales y ecológicos para cada especie, y las ilustraciones para la mayoría de las especies. Una nueva especie, *D. novogaliciana*, se describe y es endémica a la porción occidental de Nueva Galicia. Las lectotipificaciones se hacen para dos nombres, *D. nervata* y *D. pringlei*. Las ocho especies tratadas son: *D. haenkeana*, *D. inaequalis*, *D. membranacea*, *D. nervata*, *D. novogaliciana*, *D. peduncularis*, *D. resupinata*, y *D. thlaspioides*.

Dicliptera consists of about 175 species occurring in temperate and tropical regions of both the Old World and the New World. The genus has not been revised in its entirety in more than 150 years and is in need of critical taxonomic study. Mexico appears to be a regional center of diversity and endemism for *Dicliptera*. Mexican plants vary from annual herbs to large shrubs and have flowers that vary widely in size, color, and resupination. Of the approximately 75 New World species, 15 occur in Mexico, and at least eight of those are endemic to the country (Daniel, unpublished).

The Nueva Galicia region of western Mexico (Fig. 1A), as delimited by Rzedowski and McVaugh (1966) and McVaugh (1983) for the Flora Novo-Galiciana project, is recognized as a floristically rich region of the country (e.g., Graham 1993; Toledo et al. 1997). Indeed, at least 105 species of Acanthaceae occur there (Daniel 1993). Eight species of *Dicliptera* have been collected in Nueva Galicia, including one newly described below that is endemic to the region.

Based on both morphological and molecular characteristics, *Dicliptera* is included in subfamily Acanthoideae, tribe Justicieae, and subtribe Diclipterinae (McDade et al. 2000). Within the subtribe, *Dicliptera* is part of a monophyhletic lineage that also includes the Old World genera *Hypoestes* Sol. ex R. Br. and *Peristrophe* Nees, all of which are characterized by resupinate corollas. Floral resupination is achieved in all three genera by a twisting, usually 180°, of the corolla tube. In some *Dicliptera*, especially in the New World, there is no torsion in the corolla tube (i.e., resupination has been lost), and in other species the corolla is resupinate 360°. In both of these lat-

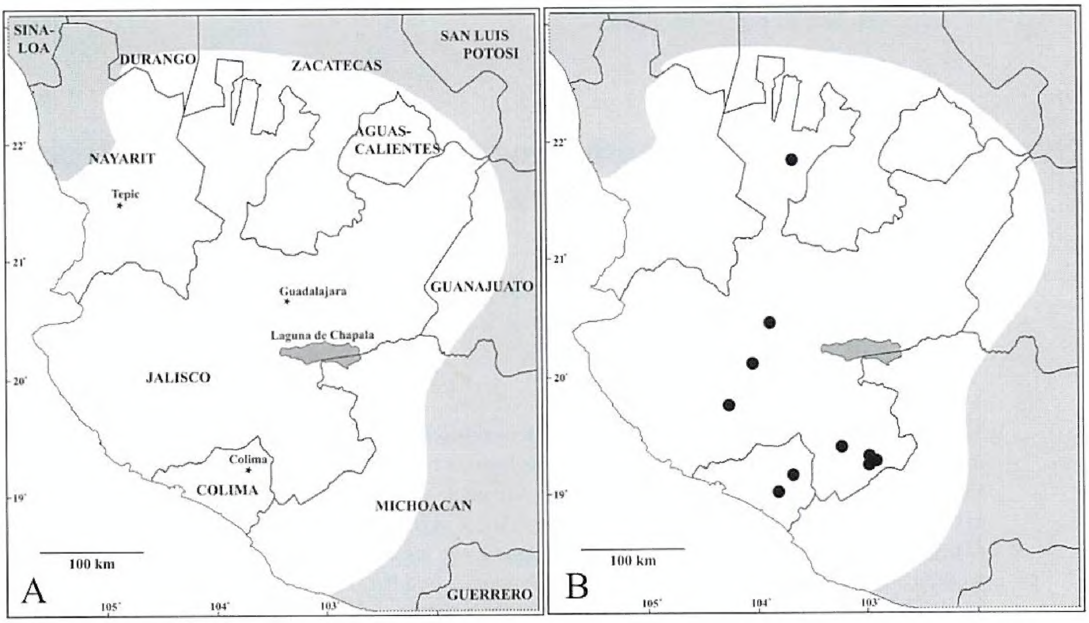


FIGURE 1. A. Map of west-central Mexico showing the boundaries of the Nueva Galicia region as delimited for the *Flora Novo-Galiciana*. B. Distribution of *Dicliptera haenkeana* in Nueva Galicia.

ter conditions, orientation of the lips of the limb is identical (i.e., upper lip entire or 2-lobed and lower lip 3-lobed). Among species of *Dicliptera* in Nueva Galicia, all three conditions are encountered: non-resupinate, resupinate 180°, and resupinate 360° (Fig. 2). All species are constant with respect to floral orientation except for *D. inaequalis*, which as circumscribed here exhibits non-resupinate corollas on some individuals and corollas that are resupinate 360° on others. Among Mexican *Dicliptera*, as exemplified by species from Nueva Galicia, small and white to pinkish (often with colored markings) corollas are resupinate 180°, whereas longer and red to orange to yellow (lacking markings) corollas are either not resupinate or resupinate 360°. Daniel and McDade (2005) noted that floral orientation, corolla size and color, and nectar sugar chemistry correlate with floral visitors among Mexican *Dicliptera*.

Pollen of *Dicliptera* in the New World is remarkably consistent (3-colporate, 6-pseudocolpate, interapertural surfaces reticulate) and offers no documented characteristics for distinguishing infrageneric taxa. This type of pollen is widespread among genera of Justicieae, including other Diclipterinae. Representative pollen grains for the eight species occurring in the Nueva Galicia region are shown in Figure 3.

Chromosome numbers have been determined for 25 species of *Dicliptera*, 15 of them restricted in distribution to the New World and 10 endemic to the Old World. All species from the New World have $n = 40$ (undoubtedly a derived number), whereas species from the Old World exhibit a diversity of numbers: $n = 10, 13, 15, 24, 26$ and ca. 30 (with $n = 13$ most commonly reported but with $n = 15$ known from taxa in Africa, Madagascar, and India [Daniel 2006; Daniel et al. 2000]). Chromosome numbers ($n = 40$) have been reported for five of the eight species occurring in the Nueva Galicia region (*D. haenkeana*, *D. inaequalis*, *D. nervata*, *D. peduncularis*, and *D. resupinata* [Daniel et al. 1984, 1990]).

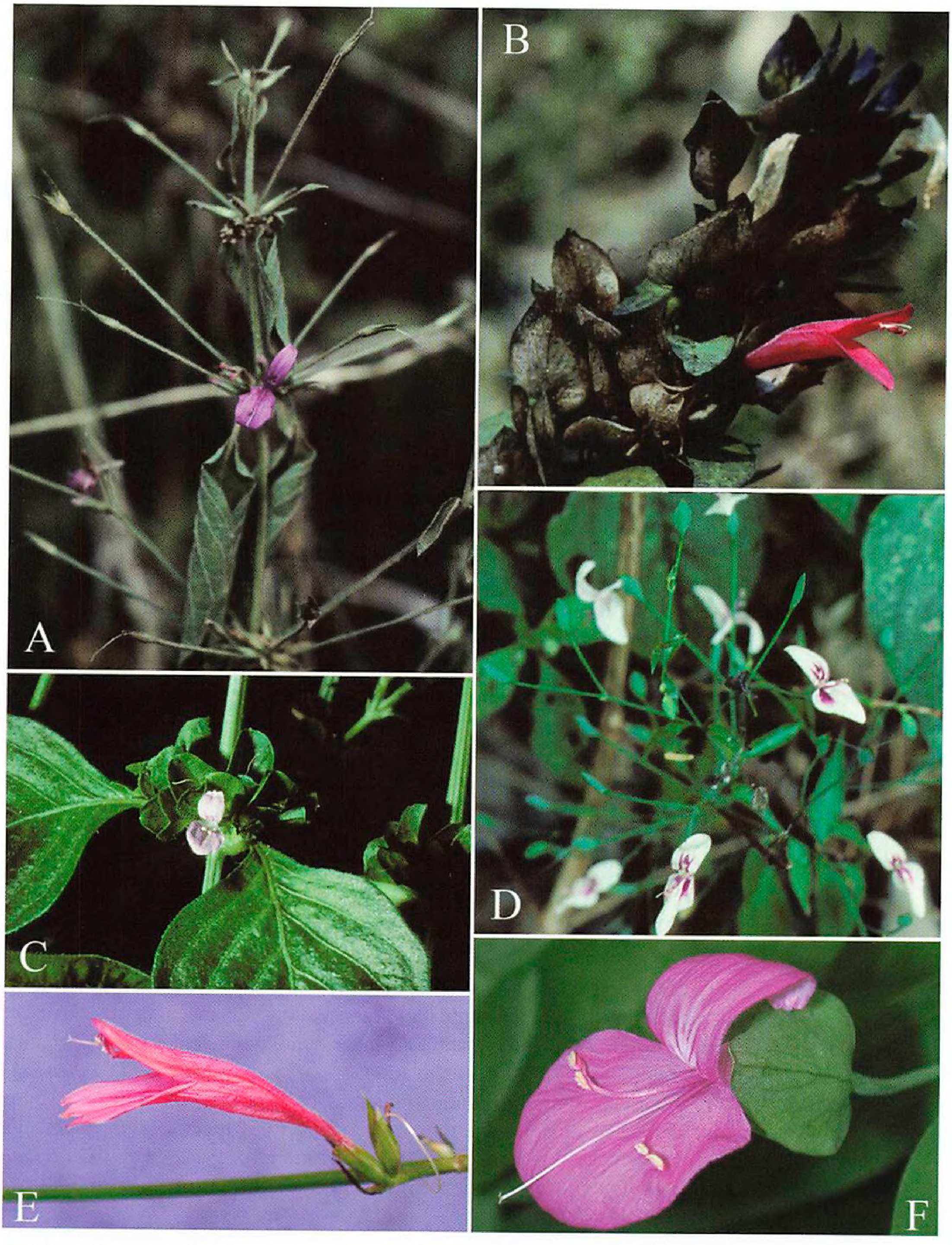


FIGURE 2. Flowers of *Dicliptera* spp. in Nueva Galicia. A. *D. haenkeana* (*Daniel & Butterwick 3275*), resupinate 180°. B. *D. novogaliciana* (*Daniel 2106*), not resupinate. C. *D. nervata* (*Daniel et al. 6282*), resupinate 180°. D. *D. thlaspioides* (*Daniel 1292* from Oaxaca), resupinate 180°. E. *D. inaequalis* (cultivated plant of *Daniel et al. 6267*), resupinate 360°. F. *D. resupinata* (cultivated plant at Tucson Botanical Garden, Arizona), resupinate 180°.

***Dicliptera* Juss., Ann. Mus. Natl. Hist. Nat. 9:267. 1807, nomen conserv.**

TYPE.— *Dicliptera chinensis* (L.) Juss. (≡*Justicia chinensis* L.).

Herbs or shrubs with cystoliths; young stems ± distinctly 6-angled in cross-section. Leaves opposite, petiolate, margin entire to subsinuate. Inflorescence of axillary cymes (= modified dichasia ?) bearing 1 or more bracteolate cymules; cymes alternate or opposite, subtended by paired bracts, sessile or pedunculate in leaf axils or in axils of inflorescence bracts forming a terminal spikelike thyrse or panicle of thyrses; cymules sessile or pedunculate, comprising an involucre of several pairs of bracteoles, outermost pair usually conspicuous and larger than inner (often hyaline) pair(s), cymule bracteoles of a pair equal or unequal in size. Flowers 1–several per cymule, sessile. Calyx deeply 5-lobed, usually reduced and hyaline, lobes equal to subequal. Corolla often resupinate (i.e., tube twisted 180° or 360°), pink to purple, red, orange, yellow, whitish, or blue, often with colored markings on lips, tube cylindric to gradually expanded distally but usually lacking a distinct throat, limb bilabiate, upper (dorsal) lip entire to emarginate, lower (ventral) lip entire to shallowly 3-lobed (position of lips reversed when corolla resupinate 180°), corolla lobes imbricate (ascending-cochlear) in bud. Stamens 2, inserted in proximal or distal ½ of corolla tube, exserted from mouth of corolla or rarely included in corolla tube, anthers 2-thecous, thecae equal to subequal in size, parallel to perpendicular, inserted at same or at different positions on filament, usually lacking basal appendages (rarely with lower theca minutely appendaged at base), dehiscing toward lower lip (i.e., flower nototribal) in species with corollas either not resupinate or resupinate 360°, dehiscing toward upper lip (i.e., flower stenotribal) in species with corollas resupinate 180°; pollen perprolate to prolate, 3-colporate, 6-pseudocolpate, pseudocolpi 2 per mesocolpium, exine reticulate; staminodes 0. Style exserted from mouth of corolla or rarely included in corolla tube, stigma 2-lobed, lobes equal. Capsule substipitate to stipitate, head ellipsoid to obovoid, retinacula present, septa with attached retinacula separating elastically and rising from inner wall of mature capsule. Seeds 2–4, homomorphic, lenticular. ($x = 40$ in New World taxa; $x = 15$ in Old World taxa)

Data in the key to and descriptions of species below are based solely on specimens from the Nueva Galicia region.

Key to *Dicliptera* in Nueva Galicia

1. Corolla 25–45 mm long, not resupinate or resupinate 360° (i.e., in some individuals of *D. inaequalis*; in either case with upper lip entire to 2-lobed and lower lip 3-lobed); thecae 1–1.6 mm long; capsule 7–9 mm long.
   2. Corolla externally pubescent with at least some glandular trichomes, lips 8–13 mm long; outer cymule bracteoles linear to lance-subulate to lanceolate to oblanceolate to obovate to hour-glass shaped, 1–6 mm wide, often glandular; inner cymule bracteoles usually glandular; plants of inland regions at 500–2000 m elevation. . . . . *D. inaequalis*
   2. Corolla externally pubescent with eglandular trichomes only, lips 12–19 mm long; outer cymule bracteoles deltate to ovate, 6–20 mm wide, eglandular; inner cymule bracteoles eglandular; plants of near coastal regions at 9–100 m elevation. . . . . *D. novogaliciana*
1. Corolla 8–21 mm long, resupinate 180° (i.e., upper lip 3-lobed and lower lip entire to 2-lobed); thecae 0.5–1 mm long; capsule 4–8 mm long.
   3. Outer cymule bracteoles reniform to cordate to deltate; inner cymule bracteoles 1.3–2.5 mm long; calyx 1.5–2.5 mm long . . . . *D. resupinata*
   3. Outer cymule bracteoles linear to ovate to elliptic to circular to hour-glass shaped to oblanceolate to widely obovate; inner cymule bracteoles 3–7 mm long; calyx 3–6 mm long.

4. Bracts subtending cymes 4–8 mm long, 1.5–2.5 mm wide; outer cymule bracteoles (adaxial surface only), inner cymule bracteoles, calyx, and corolla glandular . . . .*D. membranacea*
4. Bracts subtending cymes 1–3 mm long, 0.2–1 mm wide; outer cymule bracteoles, inner cymule bracteoles, calyx, and corolla eglandular
    5. Cymes sessile (or if subsessile, the peduncles to 3 mm long); filaments pubescent; corolla 8–12 (–15.5) mm long
        6. Cymes partially expanded (i.e., at least some cymules borne on peduncles more than 10 mm long); capsule (in ours) glabrous (or rarely sparsely pubescent near apex in *D. haenkeana*)
            7. Outer cymule bracteoles equal in size, linear-lanceolate to linear to elliptic to subcircular to obovate to oblanceolate . . . . *D. haenkeana*
            7. Outer cymule bracteoles conspicuously unequal in size, linear to linear-lanceolate to oblanceolate to hour-glass shaped . . . . *D. peduncularis*
        6. Cymes contracted (i.e., all cymules sessile or rarely borne on peduncles to 1 mm long); capsule usually pubescent . . . . *D. nervata*
    5. Cymes pedunculate, peduncles (3–) 15–25 mm long; filaments glabrous; corolla 14–18 mm long . . . .*D. thlaspioides*

Dicliptera haenkeana Nees in A. de Candolle, Prodr. 11:487. 1847.

Diapedium haenkeanum (Nees) Kuntze, Revis. Gen. Pl. 2:485. 1891.

TYPE.— MEXICO. State Unknown: without locality or date, T. Haenke s.n. (holotype: K ex hb. Hooker; possible isotypes [i.e., Haenke 986 collected in Mexico in 1791]: PR! PRC!).

Dicliptera rigidissima Miranda, Anal. Inst. Biol. Univ. Nac. México 15:30. 1944.

TYPE.— MEXICO. **Puebla**: Cerro de la Cruz, cerca de Raboso, Matamoros, 5 Oct 1942, *F. Miranda 2310* (holotype: MEXU!).

Annual or perennial herbs to 1.5 m tall; cymes sessile to subsessile (peduncles to 1 mm long) from axils of leaves (distal leaves sometimes reduced in size); cymules sessile to pedunculate (at least some distinctly pedunculate on each plant, peduncles to 55 mm long); outer cymule bracteoles linear-lanceolate to linear to elliptic to subcircular to obovate to oblanceolate, 1–5.5 mm wide, those of a pair equal in size; corolla resupinate 180°, pinkish (usually with darker reddish pink spots on lips), 8–12 mm long, externally eglandular; capsule 5–7 mm long, glabrous or sparsely pubescent near apex.

ILLUSTRATION.— Miranda (1944:31).

PHENOLOGY.— Flowering: October–March; fruiting: October–March.

DISTRIBUTION AND HABITAT.— Endemic to Mexico (Colima, Guerrero, Jalisco, México, Michoacán, Morelos, Puebla, Zacatecas); plants in Nueva Galicia occur (often along watercourses) in thornscrub, tropical deciduous forests, tropical subdeciduous forests, riparian forests, and disturbed areas (e.g., agricultural lands, roadsides) at elevations of 200–1410 m (Fig. 1B).

Dicliptera haenkeana appears to differ from *D. peduncularis* primarily by its paired outer cymule bracteoles that are equal (vs. conspicuously unequal) in size. The shape of the outer cymule bracteoles varies from linear-lanceolate to linear to subcircular to oblanceolate to obovate. Two collections with conspicuously differently shaped bracteoles were collected at the same locality: broadly elliptic to subcircular to obovate (*Anderson & Anderson 6156*) and linear to narrowly elliptic to oblanceolate (*Anderson & Anderson 6155*).

Nueva Galicia Specimens Examined.— **Colima**: Microondas La Cumbre, 1.9 km E of Río Salado on Hwy. 110 SE of Colima, *T. Daniel 5290* (CAS); Mpio. Colima, Valley del Río Salado, 5–7 km E de Colima por carr. a Pihuamo, *S. Koch et al. 89160* (CAS, MICH); Mpio. Tecomán, Tecolapa, Cerro La Salada, *F. Leger CUIDA1070* (CAS). **Jalisco**: ca. 10 km N of Juchitlán toward Guadalajara, *W. Anderson & C. Anderson 6155* (MICH), *6156* (MICH); along road between Tepalcatepec and Tecalitlán, 18.4 mi SE of Jilotlán, *T. Daniel & M. Butterwick 3275* (ASU, CAS, MEXU, MO); Mpio. Tecalitlán, road from Sierra de los Corales to Tepalcatepec, *J. Dieterle 3053* (MICH); Mpio. San Martín Hidalgo, Sierra de Quila, 200 m SO de Río Grande, *J. Guerrero N. 494* (MICH); Mpio. Autlán, 10.7 km N de Autlán, carr. Autlán–El Grullo, *E. Lott & P. Davila 2722* (CAS, RSA); Mpio. Villa Guerrero, 41 km SW de Villa Guerrero, camino a Chimaltitlán, *E. Lott et al. 2021* (CAS); 3–12 km E and SE of Jilotlán de los Dolores, *R. McVaugh 24634* (MICH); Mpio. Jilotlán de los Dolores, 20 km SE of Jilotlán de los Dolores toward Tepalcatepec, ca. 19°18′18"N, 102°54′34"W, *V. Steinmann & Y. Ramírez A. 4757* (RSA).

Dicliptera inaequalis **Greenm., Proc. Amer. Acad. Arts 39(5):90. 1903, as "inequalis."**
Type.— MEXICO. **Morelos**: Cuautla, near Cuernavaca, 1250 m, 30 May 1901, *C. Pringle 9665* (holotype: GH; isotype: US!).

Dicliptera aquatica Leonard, Kew Bull. 1938:70. 1938.
Type.— MEXICO. **México**: Distr. Temascaltepec, San Lucas del Maíz, 4 Feb 1933, *G. Hinton 3337* (holotype: K! isotypes: F! MEXU! US!).

Perennial herbs or shrubs to 3.5 m tall, infrequently epiphytic; cymes sessile to pedunculate (peduncles to 90 mm long) from leaf axils or from axils of bracts in spicate to subspicate axes; cymules sessile or pedunculate (peduncles to 25 mm long); outer cymule bracteoles linear to lance-subulate to lanceolate to elliptic to oblanceolate to obovate to hour-glass shaped, 1–6 mm wide, those of a pair subequal to unequal in size; corollas not resupinate or resupinate 360°, red, maroon, salmon, pinkish, orangish, or yellow, 25–40 mm long, externally glandular; capsule 7–9 mm long, pubescent.

Illustration.— None found.

Phenology.— Flowering: November–June; fruiting: February–June.

Distribution and Habitats.— Endemic to Mexico (Colima, Guerrero, Jalisco, Michoacán, Morelos, Nayarit, Querétaro, Zacatecas); plants in Nueva Galicia occur (especially along watercourses) in disturbed situations (e.g., roadsides), tropical deciduous forests, tropical subdeciduous forests, oak forests, mesophytic montane forests, and pine forests at elevations of 500–2000 m (Fig. 4A).

Daniel and Acosta C. (2003) provided a comprehensive description of this species from the Bajío Region of central Mexico. It superficially resembles *D. sciadephora* Donn. Sm. from southern Mexico and Central America (*cf.* Daniel 1995), but that species has generally more open inflorescences (with peduncles of cymes to 105 mm long and peduncles of cymules to 73 mm long), longer (9–11 mm) capsules, seeds bearing elongate papillae with retrorse barbs (vs. rounded papillae lacking retrorse barbs), and non-resupinate corollas. Plants of *D. inaequalis* in the Nueva Galicia region comprise a rather heterogeneous assemblage with respect to pubescence, contraction vs. expansion of the inflorescence, size and shape of the outer cymule bracteoles, corolla color, insertion of the anther thecae (subequally inserted to superposed), and capsular pubescence (only eglandular or with both glandular and eglandular trichomes). Remarkably, both plants with non-resupinate corollas (e.g., *Daniel & Bartholomew 4809, Flores F. & Ramirez R. 2595, Webster 1077*) as well as those bearing corollas with a 360° twist in the tube (e.g., *Daniel & Bartholomew 4860, Lott et al. 977, McVaugh 25728, Ornelas U. & García C. 1589, Soto N. 8193, Villa C. & Chávez L. 627*) are represented among collections of this species. In both floral presentations, the

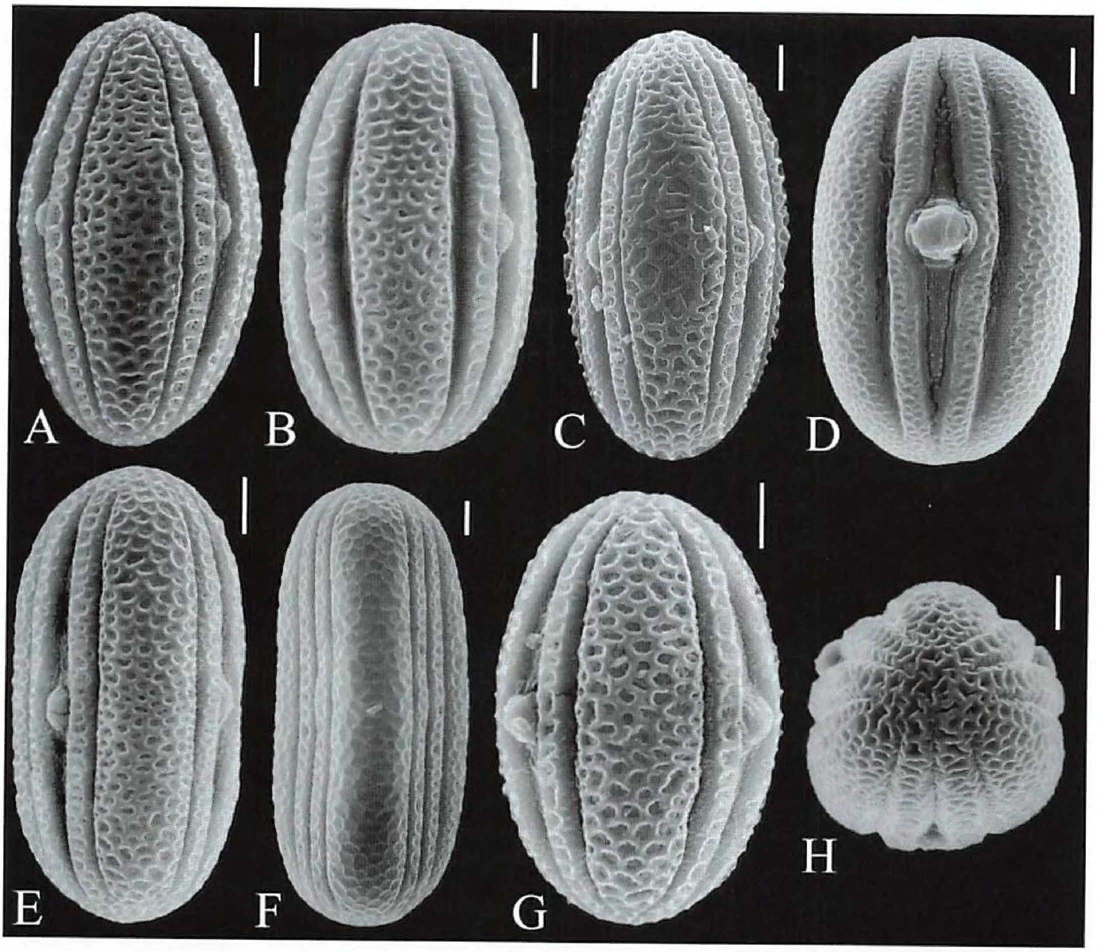


FIGURE 3. Pollen of *Dicliptera* in Nueva Galicia. A. *D. thlaspioides* (*Breedlove 35983*), interapertural view. B. *D. nervata* (*Daniel 4009*), interapertural view. C. *D. membranacea* (*Anderson & Anderson 5984*), interapertural view. D. *D. inaequalis* (*Daniel & Bartholomew 4860*), apertural view. E. *D. peduncularis* (*Daniel 1262* from Oaxaca), interapertural view. F. *D. novogaliciana* (*Daniel & Bartholomew 4877*), interapertural view. G. *D. haenkeana* (*Daniel 5290*), interapertural view. H. *D. resupinata* (*Daniel 6865* from Baja California Sur), polar view. All scales = 5 µm.

lower lip is 3-lobed (Fig. 2E). No correlations are evident between either corolla color or geography and resupination in *D. inaequalis*. So far as is known, this is the only species of *Dicliptera* with both non-resupinate and resupinate corollas. Whether the various morphological forms currently recognized as constituting this species complex should be treated as distinct taxa deserves additional study. Extreme forms of the species appear superficially very different from one another.

NUEVA GALICIA SPECIMENS EXAMINED.— **Colima**: Mpio. Comala, Rancho El Jabalí, ca. 1.5 km E of Hacienda San Antonio, vic. of Lagos Calabozo and Epazote, 19°26′N, 103°40.5′W, *T. Daniel et al. 6267* (CAS); Mpio. Comala, 20 km NE de Comala, carr. a San Antonio, altar de la Virgen de Guadalupe, *E. Lott & A. Solís M. 340* (CAS); Mpio. Comala, Rancho El Jabalí, 22 km (air) NNW of Colima, near Hac. San Antonio on hwy. to Comala, ca. 19°27′N, 103°43′W, *A. Sanders et al. 10680* (CAS, RSA); Mpio. Comala, Rancho El Jabalí, 22 km (air) NNW of Colima, road to Lago Epazote, ca. 19°27′N, 103°42.5′W, *L. Vazquez V. & B. Phillips 615* (CAS). **Jalisco**: Mpio. Tecalitlán, Sierra del Alo, cerca de San Isidro a lo largo de la brecha que va a Jilotlán de los Dolores, *M. Cházaro B. et al. 4577* (IBUG); 20.9 mi NE of La Huerta and 14.7 mi SW of turn to Ahuacapan S of Autlán on Hwy. 880, *T. Daniel 2117* (ASU, CAS, MEXU), *2120* (CAS); between

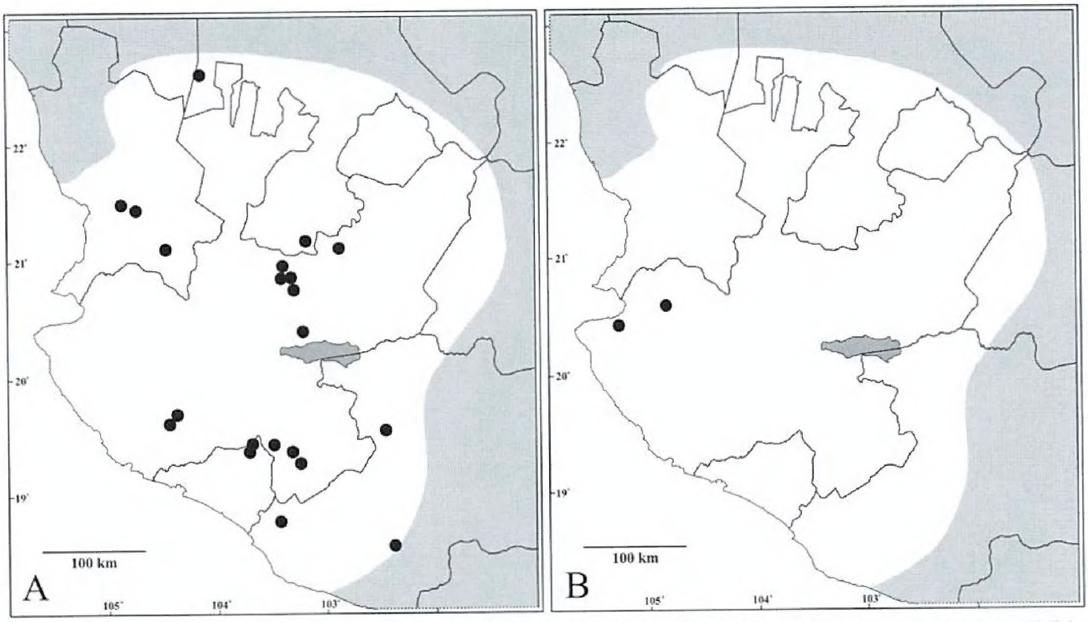


FIGURE 4. A. Distribution of *Dicliptera inaequalis* in Nueva Galicia. B. Distribution of *D. membranacea* in Nueva Galicia.

Tesistán and San Cristóbal de la Barranca, 10.6 mi S of bridge over Río Santiago, *T. Daniel & B. Bartholomew 4809* (CAS, MICH, MO); between Autlán and La Huerta, ca. 2.1 mi S of summit of pass (Puerto Los Mazos), *T. Daniel & B. Bartholomew 4860* (CAS, MICH, MO); Mpio. Casimiro Castillo, El Tigre, 6–7 km N de Casimiro Castillo, 12–13 km SSW de Autlán, 19°40′N, 104°26′W, *L. Guzmán & G. López 726* (IBUG); La Barranca, *M. Jones 23150* (CAS, MO); Mpio. Tonila, 21.2 km SW de Atenquique, carr. Tonila-Atenquique, *E. Lott et al. 977* (CAS, MICH, MO); Mpio. Autlán, 10.5 km S de Autlán, *R. Ornelas U. & J. García C. 1589* (MICH); Guadalajara, *C. Pringle S-884* (GH); mountains near Lake Chapala and Guadalajara, *C. Pringle 5344* (GH, MEXU, US); Guadalajara, *B. Reko 4602* (US); Mpio. Casimiro Castillo, 10–11 km NNE de Casimiro Castillo, 10–11 km SSW de Autlán, 19°41.5′N, 104°25′W, *E. Sánchez & L. Guzmán 15* (IBUG); Mpio. Tecalitlán, 14 km SE de Llanitos, brecha a Canutillo, *J. Villa C. & J. Chávez L. 627* (CAS, MICH); Mpio. de Zapopán, Nacimiento del Río Atlicolte en arroyos de Copala, *L. Villarreal 4903* (IBUG); Mpio. Zapopán, Arroyo de las Milpillas, carretera a San Cristóbal de la Barranca, *L. Villarreal de Puga 7314* (IBUG); Mpio. de Yahualica, NE de Cuquio, *L. Villarreal de Puga & S. Carvajal H. 10349* (ENCB, IBUG). **Michoacán**: Mpio. Los Reyes, 1.5 km SE de Los Reyes, *S. Carvajal H. & A. Moreno C. 895* (IBUG); along road from Caramicus to Tumbiscatio, 12.6 km N of Tumbiscatio, 18°35.024′N, 102°20.717′W, *J. Porter & V. Steinmann 14592* (RSA); Mpio. Chinicuila, camino Villa Victoria–Palos Marías, *J. Soto N. et al. 8193* (BIGU, CAS). **Nayarit**: Mpio. Ahuacatlán, 8 km W de Jala, camino a la estación de microondas, Volcán El Ceboruco, 21°05′N, 104°30′W, *G. Flores F. & R. Ramirez R. 2595* (CAS); Mpio. Jala, Volcán El Ceboruco, 12 km NE de Jalpan, 21°07′N, 104°30′W, *G. Flores F. & R. Ruenes 1884* (CAS, MICH); Tepic, *E. Palmer 2001* (US); Cerro Sanganguey, cerca de Tepic, *L. Paray 2707* (ENCB); KM 9 del camino de Jala a la estación de microondas (Volcán El Ceboruco), 21°07′N, 104°30′W, *O. Téllez V. & P. Magaña 8217* (CAS). **Zacatecas**: foothills of Sierra de los Huicholes, 12–18 km SW of San Juan Capistrano, and 20–25 km SW of crossing of Río Atenco (Chapalagana), *R. McVaugh 25728* (MICH); 8 mi S of *Moyahua*, *J. Webster 1077* (MICH).

Dicliptera membranacea **Leonard, J. Wash. Acad. Sci. 31:102. 1941.**

TYPE.— GUATEMALA. **Escuintla**: between Río Jute and Río Pantaleón on road between Escuintla and Santa Lucía Cotz, 540–720 m, 24 Jan 1939, *P. Standley 63524* (holotype: US! isotype: F!).

Perennial herbs to 5 dm tall; cymes sessile to subsessile (peduncles to 2 mm long) from axils

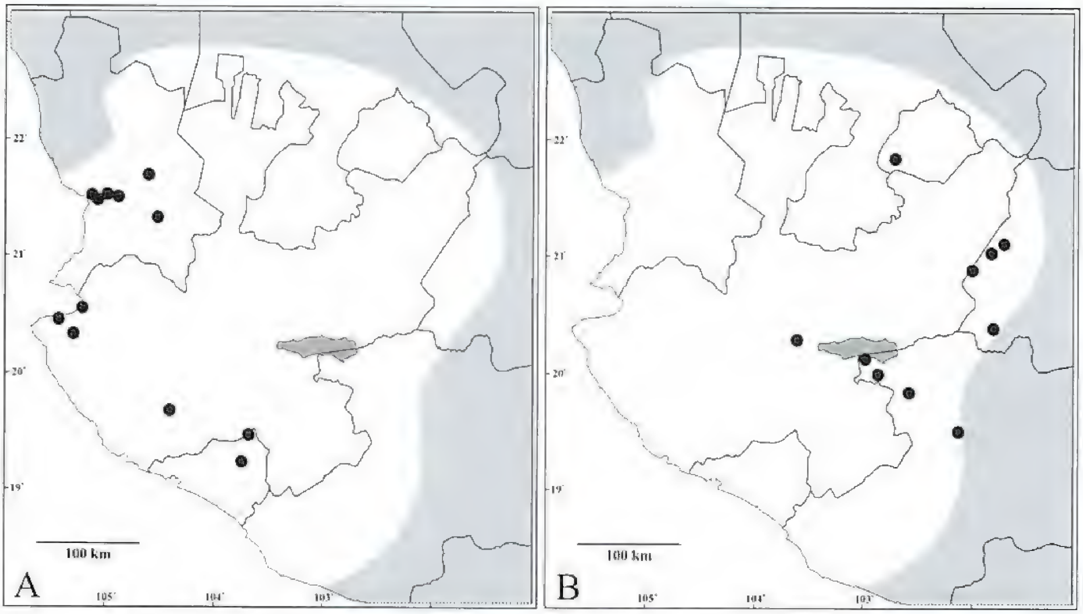


FIGURE 5. A. Distribution of *Dicliptera nervata* in Nueva Galicia. B. Distribution of *D. peduncularis* in Nueva Galicia.

of distal leaves and bracts (often forming a dense terminal spikelike thyrse); cymules sessile; outer cymule bracteoles obovate, 1.8–4 mm wide, those of a pair subequal to unequal in size, often whitish proximally and dark green or purplish distally; corolla resupinate 180°, rose-purple and cream, 10–11 mm long, externally glandular (glandular trichomes sometimes sparse); capsule 4.5 long, pubescent.

ILLUSTRATION.— Leonard (1941:103).

PHENOLOGY.— Flowering: December–May; fruiting: December.

DISTRIBUTION AND HABITAT.— Mexico (Chiapas, Guerrero, Jalisco) and Guatemala; plants from Nueva Galicia occur in tropical subdeciduous forest, and moist shady mixed forest of *Magnolia*, *Fraxinus*, *Prunus*, *Garrya*, *Cornus*, etc. at elevations of 50–1200 m (Fig. 4B).

Daniel (1995) provided a comprehensive description of this species in Chiapas. Considerable variation with respect to the size of outer cymule bracteoles and corollas is evident among specimens identified as *D. membranacea* from throughout its range. Plants from the Nueva Galicia region have smaller bracteoles and corollas than the type from Guatemala.

NUEVA GALICIA SPECIMENS EXAMINED.— **Jalisco**: Sierra de San Sebastián, 15–30 km (air) N of Mascota on road to San Sebastián, *W. Anderson & C. Anderson 5984* (MICH); Mpio. Pto. Vallarta, carr. Pto. Vallarta–Tomatlán, 38 km de Pto. Vallarta, *Nieves et al. 27* (IBUG).

Dicliptera nervata **Greenm., Proc. Amer. Acad. Arts 39:90. 1903.**

TYPE.— MEXICO. **Morelos**: Cuantla, near Cuernavaca, 1230 m, 31 May 1901, *C. Pringle 9664* (lectotype, designated here: GH! isolectotypes: K, MEXU! MO! NY, US!).

Perennial herbs to 3.5 dm tall; cymes sessile or subsessile (peduncles to 3 mm long), often clustered at nodes; cymules sessile to subsessile (peduncles to 1 mm long); outer cymule bracteoles ovate to widely obovate, 3–9.5 mm wide, those of a pair equal to unequal in size; corolla resupinate 180°, white to pink to pinkish purple, 9–12 (–15.5) mm long, externally eglandular; capsule 5–6 mm long, pubescent (rarely nearly glabrous on plants occurring near Puerto Vallarta).

ILLUSTRATION.— None found.

PHENOLOGY.— Flowering: November–May; fruiting: November–May.

DISTRIBUTION AND HABITAT.— Endemic to Mexico (Colima, Jalisco, Morelos, Nayarit, Sinaloa); plants from Nueva Galicia occur in tropical subdeciduous forests, oak forests, mesophytic montane forests, pine forests, and disturbed areas (e.g., roadsides, cafetales) at elevations from near sea level to 1300 m (Fig. 5A).

In the protologue Greenman (1903) cited two syntypes, the Pringle collection designated above as lectotype, and *Bilimek 344* (syntype: GH!) from Cuernavaca in Morelos (collected 8 January 1866).

NUEVA GALICIA SPECIMENS EXAMINED.— **Colima**: Mpio. Comala, Rancho El Jabalí, ca. 1.5 km E of Hacienda San Antonio, ca. 19°26′N, 103°41′W, *T. Daniel et al. 6282* (CAS, IBUG, K, MEXU, MICH, MO, NY, US); Mpio. Colima, Hacienda Albaradita, 1 km W of Cd. Colima, *C. Gilly et al. 62* (MICH); Rancho El Jabalí, 22 km (air) NNW of Colima in SW foothills of Volcán de Colima, ca. 19°26.7′N, 103°41.9′W, *A. Sanders et al. 11074* (MO, US). **Jalisco**: Hwy. 80 between Autlán and La Huerta, 8.7 mi S of turn to Ahuacapan, *T. Daniel & B. Bartholomew 4863* (CAS, MICH); ca. 2 km S of Pto. Vallarta, *C. Feddema 2503* (MICH); Mpio. Puerto Vallarta, entre El Jorullo y El Hundido, *R. González T. 597* (MICH); Mpio. Cabo Corrientes, 5 km N of El Tuito, *R. McVaugh 25500* (MICH); S of Pto. Vallarta, *Y. Mexia 1110* (CAS, DS, MICH, MO, US); Yelapa, Ensenada Yelapa, Río Tuito, 20°29′N, 105°27′W, *T. Van Devender & R. Van Devender 94-12* (CAS). **Nayarit**: Mpio. Nayar, Colorado de la Mora, Arroyo de Los Negros, 150 m NW del poblado, *O. Bravo-Bolaños 2183* (MICH); Rte. 28, KM 20–21, *T. Croat 45293* (MO); along Rte. 28, 1.8 mi W of Jalcocotán between Tepic and Santa Cruz, *T. Croat 45318* (CAS, MO); between Tepic and Santa Cruz, 1.5 mi W of El Izote and 12.7 mi E of Jalcocotán, *T. Daniel 2029* (ASU, CAS, IBUG, MEXU); above La Bajada (near La Palma), ca. 12 mi (air) SE of San Blas, *T. Daniel 4009* (ASU, CAS); Hwy. 66 from Tepic to Miramar, 1.8 mi E of turn to Mecatán, *T. Daniel & B. Bartholomew 4732* (CAS, MICH); Hwy. 66 from Tepic to Miramar, 17.1 mi NE of Tecuitata, *T. Daniel & B. Bartholomew 4744* (CAS, IBUG, MICH); road from Hwy. 15 to Cofradia, 8.4 mi E of Hwy. 15 and ca. 1–2 mi NE of Santa María del Oro, *T. Daniel & B. Bartholomew 4781* (CAS); Mpio. Tepic, 11 km W de Jalcocotán, carr. a Tepic, 21°31′N, 105°02′W, *G. Flores F. & R. Ramírez R. 2492* (MICH, MO); Tepic, *M. Jones 23397* (MO, POM); La Bajada, SE of San Blas, *E. Lehto 24230* (ASU); Tepic, *E. Palmer s.n.* (MICH).

***Dicliptera novogaliciana* T.F. Daniel, sp. nov.**

TYPE.— MEXICO. **Jalisco**: Cuastecomate Bay at NW end of Melaque, ca. 1 mi NW jct. Hwy. 200 to Barra de Navidad, ca. 19°13′N, 104°44′W, 9 m, deciduous forest, 19 Mar 1982, *T. Daniel 2106* (holotype: CAS! isotypes: ASU! BR! ENCB! IEB! IBUG! K! MEXU! MICH! NY! US!).

Herbae perennes vel frutices. Cymae subsessiles vel pedunculatae in axillis foliorum, pedunculi 1–23 mm longi. Cymulae (1–)2–4 in cyma, pedunculatae, pedunculi 2–13 mm longi. Cymulae bracteolae externae ovatae vel deltatae, 10–23 mm longae, 6–20 mm latae, binatim subaequales vel inaequales. Corolla non resupinata, roseo-purpurea vel rubra, 35–45 mm longa. Stamina 20–33 mm longa, thecis 1.2–1.6 mm longis. Capsula 7–8.5 mm longa, glabra.

Erect perennial herbs or shrubs to 2.5 m tall. Young stems hexagonal, internodes nearly glabrous to scurfy (i.e., with irregular ± trichomelike protuberances ca. 0.01 mm long), nodes pubescent with flexuose to antrorse eglandular trichomes to 0.6 mm long. Leaves petiolate, petioles to 35 mm long, blades lanceolate to ovate to elliptic, 14–158 mm long, 5.5–70 mm wide, 1.9–5 times longer than wide, acuminate at apex, acute at base, surfaces sparsely pubescent with antrorse eglandular trichomes (especially along major veins). Cymes (alternate to) opposite, subsessile to pedunculate in leaf axils, 1–2 per axil, peduncles 1–23 mm long. Bracts subtending cymes ± acicular to subulate to oblanceolate, rarely petiolate, 1.5–10 mm long, 0.2–4 mm wide, abaxial surface glabrous to ± scurfy. Cymules (1-) 2–4 per cyme, pedunculate, peduncles 2–13 mm long. Outer

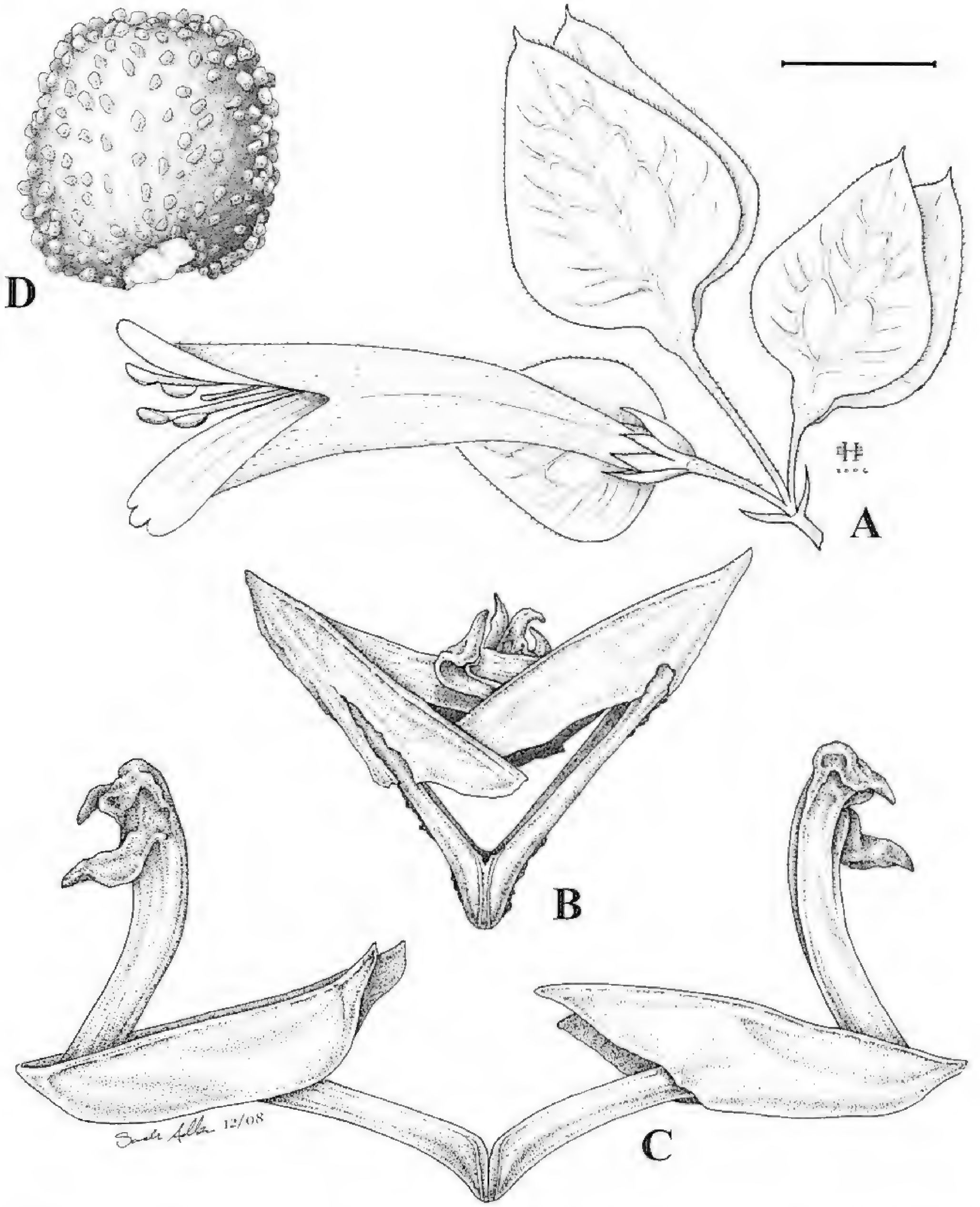


FIGURE 6. *Dicliptera novogaliciana*, A. Cyme with three cymules and one flower, one outer cymule bracteole removed to show inner cymule bracteoles, calyx, and base of corolla (from specimens and images of *Daniel 2106* and *5279*). B. Capsule partially dehisced (*Daniel & Bartholomew 4877*). C. Capsule fully dehisced (*Daniel 2109*). D. Seed (*Lott et al. 2222*). Scale for A = 1 cm, for B and C = 2.4 mm, and for D = 0.85 mm. (A. Drawn by E. Hunter. B–D. Drawn by Sarah Adler.)

cymule bracteoles ovate to deltate, 10–23 mm long, 6–20 mm wide, those of a pair subequal to unequal in size with the larger one 1.1–1.4 times longer than the smaller one, rounded to acute and submucronate to mucronate (mucro 0.05–0.3 mm long) at apex, truncate to subcordate to cuneate at base, abaxial surface glabrous to ± scurfy, rarely with a few antrorsely appressed eglandular trichomes along major veins. Inner cymule bracteoles narrowly lanceolate to ovate, (1.5-) 3–6 mm long, 0.9–1.2 mm wide, abaxial surface glabrous or with a few antrorse eglandular trichomes to 0.2 mm long, margin ciliate. Flowers sessile, nototribic. Calyx 3–5 mm long, lobes triangular to lanceolate to ovate, 2.2–3.5 mm long, abaxially glabrous or very sparsely pubescent with antrorse eglandular trichomes to 0.2 mm long, margin ciliate. Corolla not resupinate, pinkish purple to light red to bright red, 35–45 mm long, externally pubescent with erect to flexuose to retrorse eglandular trichomes 0.2–0.5 mm long, tube 19–27 mm long, 2.5–3.5 mm in diameter near midpoint, gradually expanded distally, upper lip 12–19 mm long, entire to 2-fid, lower lip 12–18 mm long, 3-lobed, lobes 0.2–1 mm long. Stamens 20–33 mm long, inserted in proximal or distal half of corolla tube, filaments pubescent with eglandular trichomes, thecae 1.2–1.6 mm long, subparallel to subperpendicular, overlapping slightly to superposed (touching or with a gap to 0.7 mm long between thecae); pollen perprolate, 3-colporate, 6-pseudocolpate, interapertural exine reticulate. Style 33–43.5 mm long, sparsely pubescent with eglandular trichomes, stigma equally 2-lobed, lobes to 0.2 mm long. Capsule 7–8.5 mm long, glabrous. Seeds squarish, somewhat flattened laterally, 1.8–2.5 mm long, 1.5–1.9 mm wide, testa tuberculate (at least on and near margin), tubercles lacking barbs, sometimes becoming irregular and roughened ridges on faces of mature seeds.

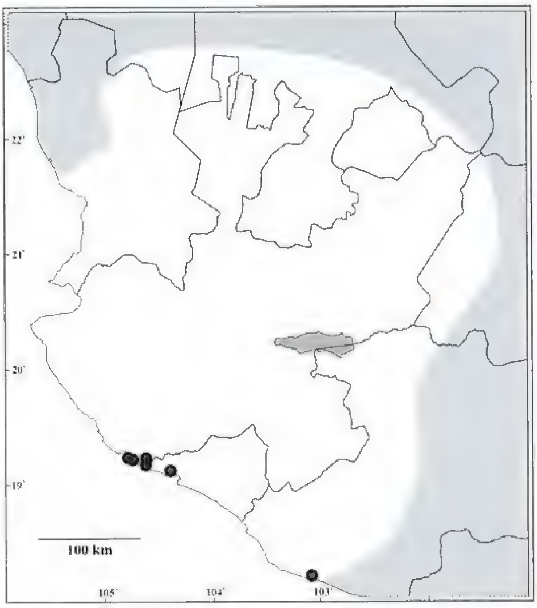


FIGURE 7. Distribution of *D. novogaliciana*.

ILLUSTRATION.— Figure 6.

PHENOLOGY.— Flowering: November–April; fruiting: November–April.

DISTRIBUTION AND HABITATS.— Coastal regions of Jalisco, Colima, and Michoacán where plants occur on rocky hills and stream banks in tropical deciduous or subdeciduous forests (with *Acacia*, *Hura*, *Brosimum*, *Celaenodendron*, *Astronium*, *Bursera*, *Colubrina*, *Tabebuia*, *Forchammeria*, *Orbignya*, and *Acalypha*) at elevations of 9–100 m (Fig. 7).

Because of a superficial resemblance of plants from coastal Nueva Galicia to the imperfectly known *D. inutilis* from Guatemala (especially in characters of the cymes and cymules), specimens here treated as *D. novogaliciana* have sometimes been identified with the former name. Study of the two known, and somewhat disparate, Guatemalan specimens of *D. inutilis* reveals that Mexican and Guatemalan plants can be distinguished by the differences in the following couplet:

1a.Internodes nearly glabrous to scurfy (i.e., with irregular ± trichomelike protuberances ca. 0.01 mm long); peduncles of cymules 2–13 mm long; abaxial surfaces of outer and inner cymule bracteoles, calyx, and corolla eglandular; calyx 3–5 mm long; capsule glabrous; plants occurring from 9–100 m in western Mexico . . . . *D. novogaliciana*
1b.Internodes ± evenly pubescent with flexuose to antrorse to retrorse eglandular trichomes 0.1–0.3 mm long; peduncles of cymules 1.5–3 mm long; abaxial surfaces of outer and inner cymule bracteoles, calyx, and corolla sometimes inconspicuously glandular; calyx 5.2–5.7 mm long; capsule pubescent; plants occurring at about 1200 m in southern Guatemala . . . . *D. inutilis*

Hinton's collection from Michoacán differs from the others by its reduced inner cymule bracteoles (1.5 mm long) and more tightly congested cymes. The smaller capsules of this collection (4–5.5 mm long) appear to be immature.

Paratypes.— **Colima**: along Hwy. 200 SE of Cihuatlán, 4.8 mi NW of Puente Miramar near Santiago, *T. Daniel 2109* (ASU, CAS, MEXU). **Jalisco**: Playa Cuastecomate at N end of Melaque, *T. Daniel 5279* (CAS), *T. Daniel & B. Bartholomew 4877* (CAS, IBUG, K, MEXU); overlooking Cuastecomate Bay at NW end of Melaque, ca. 1 mi NW jct. Hwy. 200 to B. de Navidad, *T. Daniel & M. Butterwick 3235* (CAS, MEXU, MICH); Mpio. La Huerta, 2.6 km S de la desviación a La Manzanilla, KM 11 de la carr. Barra de Navidad–Pto. Vallarta, *E. Lott et al. 2222* (CAS, MEXU); Mpio. Cihuatlán, río cerca de El Aguacate, ca. 4 km N de la carretera Melaque-Cihuatlán, brecha a Cihuatlán, *J. Magallanes 2856* (ASU, MICH); 5 mi WSW of Cihuatlán, *R. McVaugh 20793* (MICH); near Playa de Cuastecomate, 8 km NW of Navidad, *R. McVaugh & W. Koelz* 1677 (MICH); Barra de Navidad, *L. Villareal de Puga 65* (ENCB); Mpio. Barra de Navidad, cerca de la Playa Cuastecomate, *L. Villareal de Puga 5142* (IBUG). **Michoacán**: Distr. Coalcomán, Pichilinguillo, *G. Hinton et al. 15913* (MICH, RSA, SD, US).

Dicliptera peduncularis Nees in A. de Candolle, Prodr. 11:488. 1847.

Diapedium pedunculare (Nees) Kuntze, Revis. Gen. Pl. 2:485. 1891.

Type.— MEXICO. **State Unknown**: without locality or date, *A. Aschenborn* "pl. exs. n. 449" (fide protologue; syntype: herbarium not cited); **Hidalgo**: "prope los Banos" (fide protologue), *C. Ehrenberg s.n.* (syntype: B, destroyed); **Hidalgo**: "prope los Banos de Azote" (fide protologue), Oct, *C. Ehrenberg 1141* (syntype: B, destroyed; isosyntypes: BM! POM! P! PR! US!). Nees (1847) indicated that he saw specimens of this species in Aschenborn's herbarium and at B. Two syntypes (the Ehrenberg collections) were specifically cited as being at B and it may be assumed that Aschenborn's collection was in Aschenborn's personal herbarium. Alwin Aschenborn's collections are known to be at B, BR, E, JE, KIEL, and W (Lanjouw and Stafleu 1954). The two syntypes at B were destroyed, but until these and other herbaria can be searched for the remaining syntype, it seems premature to designate one of the known isosyntypes as lectotype for this species. Also in the protologue, Nees (1847) treated Aschenborn's collection and that of Ehrenberg from "prope los Banos" as an unnamed ("α") variety whereas *Ehrenberg 1141* from "prope los Banos de Azote" was treated as a different unnamed ("β") variety.

Perennial herbs to 4 dm tall; cymes sessile to subsessile (peduncles to 3 mm long) from axils of leaves (sometimes reduced in size distally); cymules sessile or pedunculate (at least some distinctly pedunculate on each plant, peduncles to 90 mm long); outer cymule bracteoles linear to linear-lanceolate to oblanceolate to hour-glass shaped, 0.5–3 mm wide, those of a pair unequal in size; corolla resupinate 180°, rose-purple to whitish, 8–10 mm long, externally eglandular; capsule 5–6 mm long, glabrous.

Illustrations.— Sánchez S. (1979: t. 297C); Daniel and Acosta C. (2003:27); Calderón de Rzedowski and Rzedowski (2004:265).

Phenology.— Flowering: October–February; fruiting: October–February.

Distribution and habitat.— Endemic to Mexico (Aguascalientes, Distrito Federal, Guanajuato, Hidalgo, Jalisco, Michoacán, México, Oaxaca, Puebla, San Luis Potosí); plants in Nueva Galicia occur in disturbed areas (pastures, roadsides) at elevations of 1300–1920 m (Fig. 5B).

Daniel (1999) provided a comprehensive description of this species for plants in the Tehuacán-Cuicatlán Valley, and Daniel and Acosta C. (2003) described plants from the Bajío Region of central Mexico. The entities recognized by Nees (1847) in the protologue differ in stems and leaves of the vegetative portions (hirsute vs. nearly glabrous or at least not hirsute). Variation in stems and leaves, encompassing both conditions noted by Nees (1847), can be observed among specimens from western and central Mexico. Most plants from Nueva Galicia have stems and leaves either more or less glabrous or sparsely pubescent. Dorado et al. collected plants with white flowers (*1679*) and others with "violet" flowers (*1678*) from the same population in Jalisco.

NUEVA GALICIA SPECIMENS EXAMINED.— **Aguascalientes**: Mpio. Calvillo, 1 km E of Colomos, *G. García 4107* (IEB). **Guanajuato**: Mpio. Pénjamo, 17 km W de Pénjamo, *R. Galván & J. Galván 2359* (ENCB); Mpio. Purísima, 5 km W de San Ángel, *R. Galván & J. Galván 2433* (ENCB, IEB); Mpio. Purísima, Los Tanques, cerca de El Palenque, *R. Galván & J. Galván 3243* (ENCB); Mpio. Purísima, alrededores de Jalpa de Canovas, *R. Galván & J. Galván 3259* (ENCB, IEB, MEXU, MO); just N of San Francisco del Rincón, *R. McVaugh 24285* (MICH); vic. of León, "Mendez in h. DC." (GZU). **Jalisco**: Mpio. Zacoalco de Torres, 9 mi N of Zacoalco toward Acatlán, *O. Dorado et al. 1678* (CAS, RSA), *1679* (RSA). **Michoacán**: Hwy. 15, 3 mi E Jalisco-Michoacán border in Palo Alto, *T. Daniel 1129* (CAS); Hwy. 110, 16.9 mi W jct. Hwy. 15 in Jiquilpan, *T. Daniel et al. 3294* (ASU, CAS, MEXU, MO); vicinity of Volcán Paricutín, *R. Hakala s.n.* (MICH); 3 km E and 8–10 km NE of Cotija de la Paz (ca. 1.5 km S of San Francisco) on road to Jiquilpan, *R. McVaugh 24922* (MICH).

Dicliptera resupinata (Vahl) Juss., Ann. Mus. Natl. Hist. Nat. 9:268. 1807.

Justicia sexangularis Cav., Icon. 3:2. 1795, non L. (1753). *Justicia resupinata* Vahl, Enum. Pl. 1:114. 1804. *Diapedium resupinatum* (Vahl) Kuntze, Revis. Gen. Pl. 2:485. 1891.

TYPE.— Not designated (see discussion in Daniel, 1997).

Dicliptera pseudoverticillaris A. Gray, Proc. Amer. Acad. Arts 20:308. 1885.

TYPE.— MEXICO. **Sonora**: valley of the Altar, 2 Apr 1884, *C. Pringle 27* (lectotype, designated by Daniel, 1997: GH!).

Dicliptera torreyi A. Gray, Proc. Amer. Acad. Arts 20:309. 1885. *Diapedium torreyi* (A. Gray) A. Heller, Cat. N. Amer. Pl. 7. 1898.

TYPE.— UNITED STATES. **Arizona**: unspecified collections of Thurber, Wright, Schott, Rothrock, Lemmon, and Pringle were cited (syntypes, see discussion in Daniel 1997).

Dianthera sexangularis Sessé & Moc., Pl. Nov. Hisp. 5. 1887.

TYPE.— Icones Florae Mexicanae no. 22. Original plate preserved at Hunt Institute for Botanical Documentation, Pittsburgh, Pennsylvania, USA (lectotype, designated by Daniel, 1997).

Dicliptera formosa Brandegee, Proc. Calif. Acad. Sci., ser. 2, 3:162. 1891.

TYPE.— MEXICO. **Baja California Sur**: summit of Sierra de San Francisquito, 20 Oct 1890, *T. Brandegee 455* (holotype: UC! isotypes: GH! NY).

Dicliptera resupinata var. *orbicularis* B.L. Rob. & Seaton, Proc. Amer. Acad. Arts 28:114. 1893.

TYPE.— MEXICO. **Jalisco**: barranca near Guadalajara, Oct 1891, *C. Pringle 5169* (holotype: GH; isotype: MEXU!).

Annual or perennial herbs to 1 m tall; cymes sessile to pedunculate (peduncles to 50 mm long) from leaf axils; cymules sessile to pedunculate (at least some distinctly pedunculate on each plant, peduncles to 75 mm long); outer cymule bracteoles reniform to cordate to deltate, 5–11.5 mm wide, those of a pair ± equal in size; corolla resupinate 180°, pinkish to pink-purple (rarely reported as "white") and sometimes with darker maroon markings on upper lip, 9–12 (–21) mm long, externally eglandular; capsule 4–6 mm long, glabrous.

ILLUSTRATIONS.— Wiggins (1980:190); Daniel (1997:331).

PHENOLOGY.— Flowering: October–June; fruiting: October–June.

DISTRIBUTION AND HABITATS.— Southwestern United States (Arizona, New Mexico) and western Mexico (Baja California Sur, Chihuahua, Colima, Durango, Guerrero, Jalisco, México, Michoacán, Nayarit, Sinaloa, Sonora, Zacatecas); plants from Nueva Galicia occur in tropical deciduous forests, savannahs, oak forests, pine-oak forests, pine forests, and mesophytic montane forests at elevations of 20–1500 m (Fig. 8A). Plants often are encountered in naturally (e.g., along watercourses) or artificially (e.g., roadsides) disturbed habitats, and are frequently locally abundant or weedy.

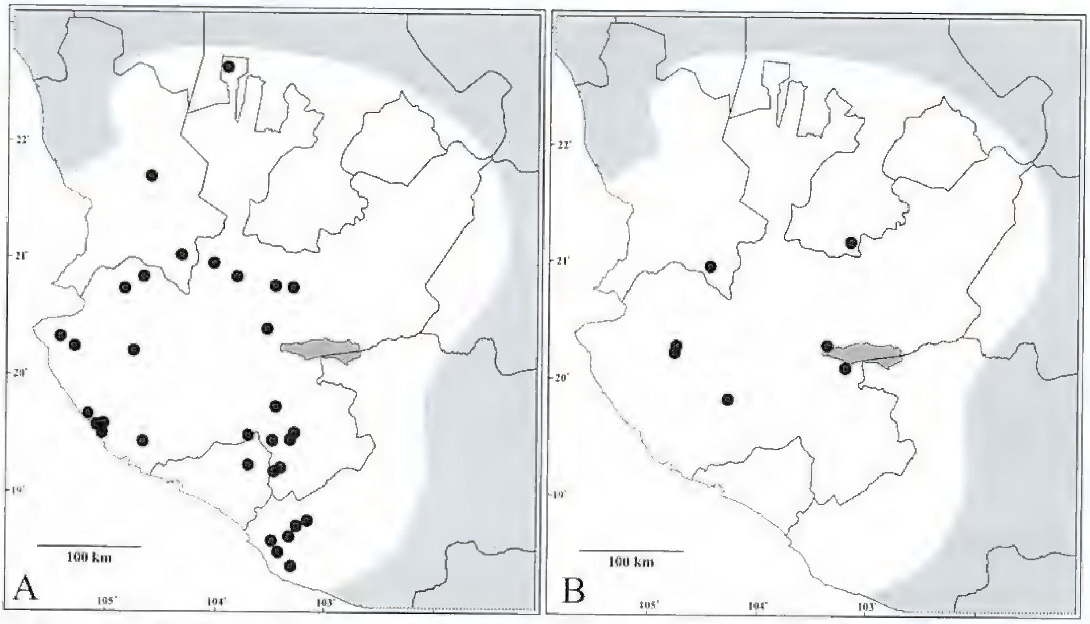


FIGURE 8. A. Distribution of *Dicliptera resupinata* in Nueva Galicia. B. Distribution of *D. thlaspioides* in Nueva Galicia.

LOCAL NAME.— "Organillo" (*Howell 10522*).

This widely distributed species exhibits considerable morphological variation with respect to the form and abundance of pubescence, degree of reduction or elaboration of the cymes, form of the outer cymule bracteoles, corolla size, and seed sculpture. Forms with ± contracted cymes are sometimes mistaken for *D. nervata*, which differs by its usually pubescent capsules and outer cymule bracteoles that are ovate to widely obovate in shape. Daniel (1997, 2004) provided a comprehensive description of this species, proposed nomenclatural adjustments, and discussed some of the morphological variation of *D. resupinata* in western Mexico.

NUEVA GALICIA SPECIMENS EXAMINED.— **Colima**: Colima, *C. Orcutt 4527* (DS, MO), *s.n.* (F); Colima, *E. Palmer 1171* (MICH). **Jalisco**: Bahía Chamela, ca. 10 km N of Chamela, *W. Anderson & C. Anderson 6139* (MICH); south-central Cabo Corrientes, 26 km W of El Tuito, 5 km W of Llano Grande (= 4 km E of Los Conejos), ca. 20°18′N, 105°31′W, *T. Cochrane et al. 11997* (CAS, MICH); between Magdalena and Nayarit border, 11 mi NW of Magdalena, 3 mi N of El Zapote, *T. Croat 45132* (MO); Hwy. 200 S of Puerto Vallarta, 7.6 mi S of El Tuito, *T. Daniel 2072* (ASU, CAS); Hwy. 110 S of Tecalitlán, 3.1 mi N of turn to Jilotlán de los Dolores, *T. Daniel 2134* (CAS); Hwy. 200, 0.3 mi N of bridge at Río San Nicolás, *T. Daniel & M. Butterwick 3226* (CAS); ca. 32 km NE of San Sebastián toward Mezquites, *T. Daniel & A. Ton 6072* (CAS); near Arroyos del Agua, ca. 10 km NW of Huejuquilla el Alto, *C. Feddema 2363* (MICH); La Barranca, Guadalajara, *M. Jones 27389* (DS, POM), *27437* (POM), *97385* (MO); Mpio. Tequila, Volcán Tequila, 1 mi S of Tequila, *A. Liston et al. 633-8* (CAS, RSA); Mpio. La Huerta, Chamela Biological Station: *E. Lott 874* (CAS, MO), *1428* (MO); *J. Miller et al. 408* (CAS, MO); *L. Pérez J. 260* (CAS, MO), *586* (MO); 2 mi N of La Cuesta, road to Talpa de Allende, *R. McVaugh 21139* (MICH, US); 3–6 km S of La Huerta, near hwy. to Bahía Navidad, *R. McVaugh 23045* (MICH); barranca near Los Camachos, hwy. near KM 20 N of Guadalajara, *R. McVaugh 24426* (MICH); ca. 12–13 km SW of Pihuamo, *R. McVaugh 24461* (MICH); Barranca de Beltrán, 12–15 km NE of Tonila, *R. McVaugh 24950* (MICH); Estación Biológica, UNAM, 8 km E of Chamela, *R. McVaugh 25123* (MICH); vicinity of Estación Biológica, UNAM, 3 km SE of Chamela, *R. McVaugh 26261* (MICH), *26286* (MICH); Rancho Paraíso, ca. 10 km SE of Chamela, *R. McVaugh 26274* (MICH); 4 mi N of Tecalitlán, *R. McVaugh & W. Koelz 1322* (MICH); 8 mi SW of Pihuamo, *R. McVaugh & W. Koelz 1514* (MICH); near San Sebastián, *Y. Mexia 1662* (CAS, DS, MICH, MO, US); Mpio. Cd. Guzmán, Laguna de Zapotlán, 6 km N de Cd. Guzmán, *A. Morones G. 217* (CAS, MICH); 21.7 mi de Chamela rumbo a Pto. Vallarta, adelante del Río San Nicolás, *L. Pérez J. 338* (CAS, MO); barranca near Guadalajara, *C. Pringle 6145* (CAS, MICH, MO, POM, US); Barranca of Guadalajara, *C. Pringle 11077* (MICH, MO, US); Mpio. Zapotitlán, Rancho El Jabali, 25 km (air) NNW of Colima, road to Lago Calabozo, NE of Lago Epazote, ca. 19°27′N, 103°41′W, *A. Sanders et al. 10440* (CAS); near jct. hwys. 15 and 80, W of Lake Chapala, *B. Templeton 9462* (RSA); Mpio. Zapotitlán, Rancho El Jabalí, 22 km NNW of Colima, El Cañón below Hac. San Antonio, *L. Vazquez V. 496* (RSA); ca. 103°44′W, 19°27′N, El Limón, *S. Zamudio et al. 4756* (CAS). **Michoacán**: Mpio. Coalcomán, 29.8 km W de Coalcomán o 22.6 km E de Villa Victoria, *C. Cowan 4913* (CAS); Mpio. Aquila, bank of Río de Ostula, *J. Hill s.n.* (MICH, RSA); Distr. Coalcomán, Aquila, *G. Hinton et al. 12619* (MICH, MO, RSA, US), *16233* (MICH, RSA, US); Distr. Coalcomán, Coalcomán, *G. Hinton et al. 12865* (MICH, RSA, US); Distr. Coalcomán, Sierra Naranjillo, *G. Hinton et al. 15774* (MICH, RSA, US); Distr. Coalcomán, Coyre, *G. Hinton et al. 15882* (MICH, RSA, US). **Nayarit**: Mpio. Nayar, Colorado de la Mora, Arroyo de Los Negros, 150 m NW del poblado, *O. Bravo-Bolaños 2189* (MEXU); archaeological site along Hwy. 15, E of Ixtlán, ca. 10 mi ESE of Ahuacatlán, *T. Daniel & B. Bartholomew 4787* (CAS); Islas Marías, María Madre, *J. Howell 10522* (CAS); Islas Marias, María Madre, *H. Mason 1798* (CAS). **Zacatecas**: Mpio. Moyahua, Cerro Los Pochotes, 9 km S de Moyahua por la carretera Méx 54, tramo Moyahua–Ixtlahuacá del Río (Jalisco), *E. Enríquez E. and J. Balleza C. 1724* (MEXU).

Dicliptera thlaspioides **Nees in A. de Candolle, Prodr. 11:474. 1847.**

Diapedium thlaspioides (Nees) Kuntze, Revis. Gen. Pl. 2:485. 1891.

Type.— MEXICO. Morelos: "Cordillière de Guchilaque," [fide specimen; = Cordillera de Huitzilac, near Cuernavaca], "Americâ meridionali, ad latus occidentale cordillerae" [fide protologue], *L. Berlandier 1013* (holotype: G ex hb. Moricand, photos: GH! MICH! NY! US! isotype: GZU!).

Dicliptera pringlei Greenm., Proc. Amer. Acad. Arts 32:302. 1897.

Type.— MEXICO. Morelos: lava beds, near Cuernavaca, 3 Nov 1896, *C. Pringle 6602* (lectotype, designated here: GH! isolectotypes: CAS! K, MEXU! NY! PR! PRC! US!).

Annual to perennial herbs to 8 dm tall; cymes pedunculate (peduncles 3–25 mm long) from axils of leaves (sometimes reduced to bracts distally), forming an open terminal leafy panicle; cymules pedunculate (peduncles 10–35 mm long); outer cymule bracteoles widely elliptic to circular, 4.4–7 mm wide, those of a pair equal in size; corolla resupinate 180°, whitish to cream with pinkish-purple markings on lips, 14–18 mm long, externally eglandular; capsule 6–8 mm long, glabrous.

Illustration.— Daniel (1999:25).

Phenology.— Flowering: October–December; fruiting: October–December.

Distribution and Habitat.— Endemic to Mexico (Guerrero, Jalisco, México, Michoacán, Morelos, Nayarit, Oaxaca, Zacatecas); plants in Nueva Galicia occur in tropical deciduous forests, oak forests, and disturbed habitats (where sometimes abundant) at elevations of 300–1900 m (Fig. 8B).

Daniel (1999) provided a comprehensive description of this species. In the protologue of *Dicliptera pringlei* Greenman (1897) cited two syntypes, the Pringle collection designated above as lectotype, and *Nelson 2256* (syntype: GH! isosyntype: US!) from near Tlalixtaquilla in Guerrero (collected 10 December 1894).

Nueva Galicia Specimens Examined.— **Jalisco**: Mpio. Tuxcueca, Cerro el Alto, al S de San Nicolás, *J. Machuca N. 6738* (MICH); 2.5–4 mi N of La Cuesta, rd. to Talpa de Allende, *R. McVaugh 21199* (MICH); above W end of Lake Chapala, midway between Jocotepec and San Juan Cosalá, *R. McVaugh & W. Koelz 384* (MICH); 10 km N de La Cuesta, *J. Rzedowski 15132* (MICH); 14–15 mi N of Autlán de Navarro on road to Guadalajara (Hwy. 80), ca. 19°55′N, 104°15′W, *G. Webster & G. Breckon 15986* (GH, MICH, MO). **Nayarit**: 10 mi SE of Ahuacatlán on rd. to Barranca del Oro and Amatlán, *R. McVaugh & W. Koelz 737* (MICH).

Acknowledgments

I thank the curators of the following herbaria for access to collections in their care: ASU, BIGU, BM, CAS, DS, ENCB, F, GH, GZU, IBUG, IEB, K, MICH, MEXU, MO, NY, P, POM, PR, PRC, RSA, SD, US; biological illustration interns Erin Hunter and Sarah Adler for the drawing; and Scott Serata, microscopist with the Scanning Electron Microscopy lab at the California Academy of Sciences, for pollen images. Field studies and some herbarium visits were made possible by funding from the American Philosophical Society (research grant 1572, Johnson Fund in 1982), the National Science Foundation (research grant BSR-8609852, 1987–1989), and the California Academy of Sciences. My studies of Acanthaceae in Nueva Galicia were initially funded at the University of Michigan by Dr. Rogers McVaugh in 1979; I have been most grateful for his kind assistance during the years since then.

Literature Cited

Calderón de Rzedowski, G., and J. Rzedowski. 2004. Manual de malezas de la region de Salvatierra, Guanajuato. *Flora del Bajío y de Regiones Adyacentes*, fasc. complem. 20:1–315.

Daniel, T.F. 1993. Mexican Acanthaceae: diversity and distribution. Pages 541–558 *in* T.P. Ramamoorthy et al., eds., *Biological Diversity of Mexico: Origins and Distribution*. Oxford University Press, New York, New York, USA. 812 pp.

Daniel, T.F. 1995. Acanthaceae. Pages 1–158 *in* D.E. Breedlove, ed., *Flora of Chiapas*, pt. 4. California Academy of Sciences, San Francisco, California, USA.

Daniel, T.F. 1997. The Acanthaceae of California and the peninsula of Baja California. *Proceedings of the California Academy of Sciences*, ser. 4, 49(10):309–403.

Daniel, T.F. 1999. Acanthaceae. Pages 1–102 *in* P.D. Dávila A. et al., eds., *Flora del Valle de Tehuacán-Cuicatlán*, fascículo 23. Universidad Nacional Autónoma de México, México.

Daniel, T.F. 2004. Acanthaceae of Sonora: taxonomy and phytogeography. *Proceedings of the California Academy of Sciences*, ser. 4, 55(35):690–805.

Daniel, T.F. 2006. Chromosome numbers of miscellaneous Malagasy Acanthaceae. *Brittonia* 58:291–300.

Daniel, T.F., and S. Acosta C. 2003. Acanthaceae. Pages 1-173 *in* J. Rzedowski and G. Calderón de Rzedowski, eds., *Flora del Bajío y de Regiones Adyacentes*, fascículo 117. Instituto de Ecología, Pátzcuaro, México.

Daniel, T.F., and L.A. McDade. 2005. Floral resupination in Acanthaceae: taxonomic and geographic distributions, expression, and possible functions. *Botany 2005: Abstracts, Scientific Meeting:137*. [http://www.2005.botanyconference.org/engine/search/index.php?func = detail&aid = 27]

Daniel, T.F., K. Balkwill, and M.-J. Balkwill. 2000. Chromosome numbers of South African Acanthaceae. *Proceedings of the California Academy of Sciences*, ser. 4, 52(12):143–158.

Daniel, T.F., T.I. Chuang, and M.A. Baker. 1990. Chromosome numbers of American Acanthaceae. *Systematic Botany* 15:13–25.

Daniel, T.F., B.D. Parfitt, and M.A. Baker. 1984. Chromosome numbers and their systematic implications in some North American Acanthaceae. *Systematic Botany* 9:346–355.

Graham, A. 1993. Historical factors and biological diversity. Pages 109–127 *in* T.P. Ramamoorthy et al., eds., *Biological Diversity of Mexico: Origins and Distribution*. Oxford University Press, New York, New York, USA. 812 pp.

Greenman, J.M. 1897. Descriptions of new and little known plants from Mexico. *Proceedings of the American Academy of Arts and Sciences* 32:295–311.

Greenman, J.M. 1903. New and otherwise noteworthy angiosperms from Mexico and Central America. *Proceedings of the American Academy of Arts and Sciences* 39:69–120.

Lanjouw, J., and F.A. Stafleu. 1954. Index herbariorum, pt. 2, collectors A–D. *Regnum Vegetable* 2:1–174.

Leonard, E.C. 1941. New Acanthaceae from Guatemala. *Journal of the Washington Academy of Sciences* 31:96–105.

McDade, L.A., T.F. Daniel, S.E. Masta, and K.M. Riley. 2000. Phylogenetic relationships within the tribe Justicieae (Acanthaceae): evidence from molecular sequences, morphology, and cytology. *Annals of the Missouri Botanical Garden* 87:435–458.

McVaugh, R. 1983. *Flora Novo-Galiciana, a Descriptive Account of the Vascular Plants of Western Mexico*, vol. 14, Gramineae. The University of Michigan Press, Ann Arbor, Michigan, USA. 436 pp.

Miranda, F. 1944. Tres nuevas gamopetalas del S.O. del estado de Puebla. *Anales del Instituto de Biologíade la Universidad Nacional de México* 15:27–34.

Nees von Esenbeck, C.G. 1847. Acanthaceae. Pages 46–519 *in* A. de Candolle, ed., *Prodromus Systematis Naturalis Regni Vegetabilis XI.* Victoris Masson, Paris, France. 519 pp.

Rzedowski, J., and R. McVaugh. 1966. La vegetación de Nueva Galicia. *Contributions from the University of Michigan Herbarium* 9:1–123.

Sánchez S., O. 1979. *La Flora del Valle de Mexico*. Editorial Herrero, Cd. México. 519 pp.

Toledo, V.M., J. Rzedowski, and J. Villa-Lobos. 1997. México. Pages 97–107 *in* S.D. Davis et al., eds., *Centres of Plant Diversity, Volume 3, The Americas*. IUCN Publications Unit, Cambridge, UK. 562 pp.

Wiggins, I. 1980. *Flora of Baja California*. Stanford University Press, Stanford, California, USA. 1025 pp.

Copyright © 2009 by the California Academy of Sciences
San Francisco, California, U.S.A.

PROCEEDINGS OF THE CALIFORNIA ACADEMY OF SCIENCES

Series 4, Volume 60, No. 2, pp. 19–22, 2 figs. May 7, 2009

Justicia cuixmalensis, a New Species of Acanthaceae from West-central Mexico

Thomas F. Daniel[1] and Emily J. Lott[2]

[1]Department of Botany, California Academy of Sciences, 55 Music Concourse Drive, Golden Gate Park, San Francisco, CA 94118 U.S.A.; Email: tdaniel@calacademy.org; [2]Plant Resources Center, University of Texas at Austin, 1 University Station F0404, Austin, TX 78712 U.S.A.; Email: emilyjlott@hotmail.com

A collection from the Chamela-Cuixmala region of southwestern Jalisco, Mexico is described as a new species, *Justicia cuixmalensis*. It is distinctive among Mexican *Justicia* by the combination of its flowers that are borne on peduncles and pedicels in the leaf axils, possess a 4-lobed calyx with broad and ovate lobes, and have red-orange corollas. Infrageneric affinities of the new species are discussed, and illustrations of it are provided.

Se describe una colección de la región de Chamela-Cuixmala en el sudoeste de Jalisco, México como especie nueva, *Justicia cuixmalensis*. Se distingue entre otras especies de *Justicia* en México por la combinación de sus flores que se presentan en las axilas de las hojas en pedúnculos y pedicelos, posean un cáliz 4-lobulado con los lóbulos amplios y ovales, y tiene corollas rojo-anaranjadas. Las afinidades infragenéricas de la nueva especie se discuten, y se proporciona una ilustración.

Justicia L. is the largest genus of Acanthaceae with more than 700 species currently recognized worldwide. More than 100 species are known from Mexico, and numerous others have been collected there, but have yet to be described (Daniel 2007). One of these from the Chamela-Cuixmala region on and near the Pacific coast of Jalisco is described below. The sole collection of this species was recognized as representing a distinctive and previously undescribed *Justicia* by us in the early 1990s. Because the collection lacks fruits, we delayed publishing a description in the hope that additional collections with fruits would become available. That has not happened. Because of the distinctiveness of this species among Mexican *Justicia*, and the need to treat it in various inventory projects, we feel that it should be published based on the single known collection.

Lott (1993, 2002) discussed the location and boundaries of the ca. 13,142-hectare Reserva de la Biósfera Chamela-Cuixmala of southwestern Jalisco, and subsequently accounted for 1,149 species of vascular plants there (Lott 2002). The region, which is dominated by tropical deciduous forest, is particularly rich in Acanthaceae. Twenty-eight species of the family have been recorded from the Chamela-Cuixmala region (Lott 1993, 2002), including nine species of *Justicia*.

Justicia cuixmalensis T.F. Daniel & E.J. Lott, sp. nov.

TYPE.— MEXICO. **Jalisco**: Mpio. La Huerta, Rancho Cuixmala, rd. to Cumbres along Río Cuixmala near Cumbres 2, 19°27′N, 104°56′W, 12 Jul 1991, *E. Lott et al. 3733* (holotype: CAS! isotype: MO!). Figure 1.

Frutex usque ad 7.5 dm altus. Folia petiolata, laminae ovatae vel ellipticae, 16–39 mm longae,

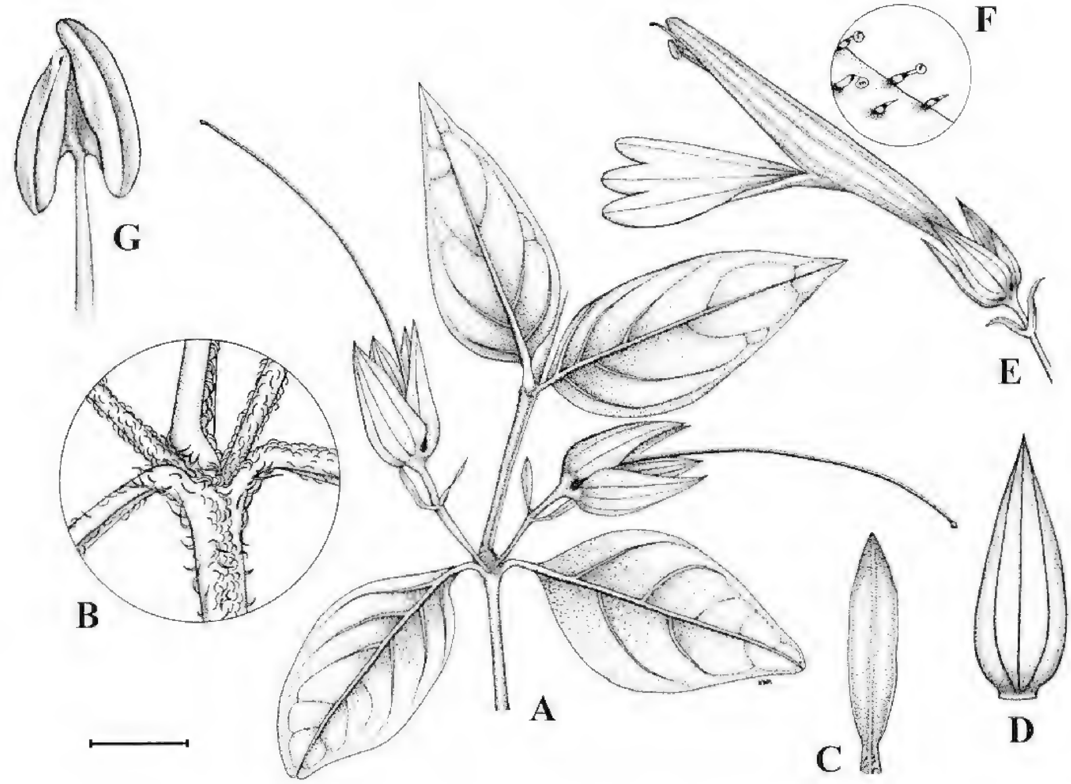


FIGURE 1. *Justicia cuixmalensis* (*Lott et al. 3733*). A. Habit. B. Node with peduncles. C. Bracteole. D. Calyx lobe. E. Flower. F. External surface of corolla. G. Distal portion of stamen with anthers. Scale for A = 9 mm, for B = 2 mm, for C = 1.8 mm, for D = 4.2 mm, for E = 7.5 mm, for F = 0.5 mm, and for G = 1.2 mm. Drawn by Nicole Bollinger.

10–20 mm latae, 1.4–2.5-plo longiores quam latiores. Flores e foliorum axillis orta, solitarii, pedunculati et pedicellati. Calyx 4-lobus, 8.5–14 mm longus, lobis homomorphis, ovatis, 2.5–5.1 mm latis. Corolla aurantiaca-rubra, 32–37 mm longa, extus pubescens trichomatibus glandulosis et eglandulosis. Stamina 15–18 mm longa, thecis 1.8–2.5 mm longis, glabris, subpariter insertis, basi ecalcaratis. Pollen granae 2-aperturatae. Capsula ignota.

Shrub to 7.5 dm tall; young stems quadrate, bifariously pubescent with retrorse, eglandular trichomes 0.2–0.7 mm long. Leaves petiolate; petioles to 3 mm long; blades ovate to elliptic, 16–39 mm long, 10–20 mm wide, 1.4–2.5 times longer than wide, rounded to acute to subacuminate at apex, rounded to acute at base, surfaces sparsely pubescent (mostly along major veins) with antrorse, eglandular trichomes to 0.3 mm long. Flowers solitary, pedunculate and pedicellate, opposite in leaf axils, peduncles 3–11 mm long, evenly pubescent with cauline type trichomes, pedicels to 3.5 mm long, pubescent like peduncles. Bracteoles lance-linear to linear (to linear-elliptic), 3–6 mm long, 0.3–0.7 (–1.2) mm wide, abaxial surface glabrous or pubescent proximally with antrorse eglandular trichomes. Calyx 4-lobed, 8.5–14 mm long, lobes ovate, 8–13.5 mm long, 2.5–5.1 mm wide, abaxially pubescent like bracteoles. Corolla orange-red, 32–37 mm long, externally pubescent with glandular and eglandular trichomes 0.1–0.2 mm long, tube 15–17 mm long, distally ampliate, upper lip 15–18 mm long, apically entire, lower lip 15–19 mm long, lobes 3–4.5 mm long, 3–4 mm wide. Stamens 15–18 mm long, filaments glabrous, thecae subequally

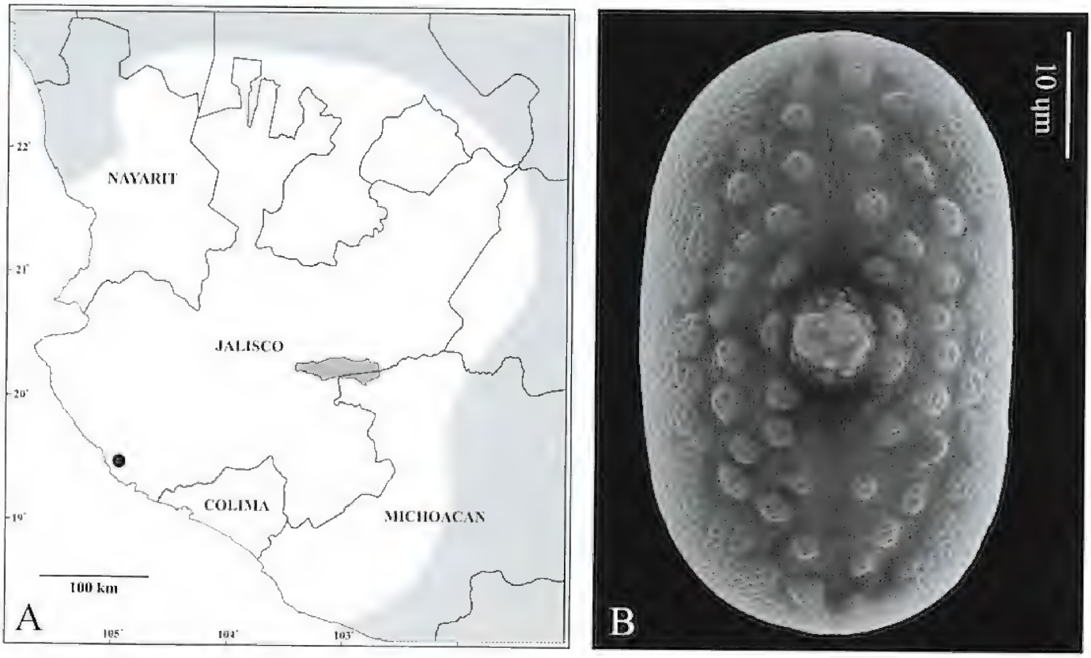


FIGURE 2. Distribution and pollen of *Justicia cuixmalensis*. A. Map of west-central Mexico showing the Nueva Galicia region and location of the sole collection of the species. B. Pollen (*Lott et al. 3733*), apertural view.

inserted, subsagittate, 1.8–2.5 mm long, glabrous, lacking basal appendages; pollen (Fig. 2B) 2-aperturate, apertures flanked on each side by 2 rows of insulae (often with adjacent peninsulae as well), exine between "trema regions" reticulate. Style 33–37 mm long, glabrous, stigma 0.2–0.3 mm long, lobes indistinct. Capsules not seen.

PHENOLOGY.— Flowering: July; fruiting: unknown.

DISTRIBUTION.— West-central Mexico (Jalisco; Fig. 2A); plants occur in tropical subdeciduous forest at elevations less than 100 meters.

Justicia cuixmalensis is distinctive among Mexican *Justicia* by its 4-lobed calyx with broad, ovate lobes. Putative relatives are not readily apparent. Based on Graham's (1988) infrageneric classification, the species shows some similarities (e.g., habit and corolla color and size) to those in the American section *Drejerella* (Lindau) V.A.W. Graham. It differs from her description of that section by its 4-lobed (vs. 5-lobed) calyx, lack (vs. presence) of thecal appendages, and 2-aperturate (vs. 3-aperturate) pollen. It also shows affinities to the American section *Simonisia* (Nees) V.A.W. Graham (e.g., habit, number of pollen apertures, and corolla form and size). Species included in that section differ by having 5-lobed calyces and purple to lilac corollas. Graham's classification fails to accommodate numerous other species of *Justicia* from the New World (e.g., Daniel 1999, 2004). Ultimately, its inflorescence structure (for solitary flowers, Graham apparently only found sessile ones in the genus) and the lack of capsules and seeds limit comprehensive morphological comparisons to other species of *Justicia*.

ACKNOWLEDGMENTS

We thank Nicole Bollinger, illustration intern at the California Academy of Sciences in 2008, for the beautiful drawing of this species; Scott Serata of the scanning electron microscopy lab at CAS; the curators at CAS, MEXU, and MO for allowing access to their collections; and the Fundación Ecológica de Cuixmala for logistical support. Funding for EJL's work in the field was provided by Conservation International, administered through UC-MEXUS.

LITERATURE CITED

DANIEL, T.F. 1999. Taxonomic and distributional notes on Neotropical *Justicia* (Acanthaceae). *Proceedings of the California Academy of Sciences*, ser. 4, 51(15):483–492.

DANIEL, T.F. 2004. A synopsis of *Justicia* section *Mesoamericanae* (Acanthaceae). *Proceedings of the California Academy of Sciences*, ser. 4, 55(8):174–183.

DANIEL, T.F. 2007. New taxa of *Justicia* (Acanthaceae) from southern Mexico and Guatemala. *Contributions from the University of Michigan Herbarium* 25:179–189.

GRAHAM, V.A.W. 1988. Delimitation and infra-generic classification of *Justicia* (Acanthaceae). *Kew Bulletin* 43:551–624.

LOTT, E.J. 1993. Annotated checklist of the vascular flora of the Chamela Bay region, Jalisco, Mexico. *Occasional Papers of the California Academy of Sciences* (148):1–60.

LOTT, E.J. 2002. Lista anotada de las plantas vasculares de Chamela-Cuixmala. Pages 99–136 *in* F.A. Noguera et al., eds., *Historia Natural de Chamela*. Instituto de Biología, Universidad Nacional Autónoma de México, Cd. México.

Copyright © 2009 by the California Academy of Sciences
San Francisco, California, U.S.A.

PROCEEDINGS OF THE CALIFORNIA ACADEMY OF SCIENCES

Series 4, Volume 60, No. 3, pp. 23–38, 6 figs., 1 table May 7, 2009

A Honey Bee from the Miocene of Nevada and the Biogeography of *Apis* (Hymenoptera: Apidae: Apini)

Michael S. Engel[1,2], Ismael A. Hinojosa-Díaz[1], and Alexandr P. Rasnitsyn[3,4]

[1] *Division of Entomology (Paleoentomology), Natural History Museum, and Department of Ecology & Evolutionary Biology, 1501 Crestline Drive – Suite 140, University of Kansas, Lawrence, KS 66049-2811; Email: msengel@ku.edu & hinojosa@ku.edu;* [2] *Division of Invertebrate Zoology, American Museum of Natural History, Central Park West at 79th Street, New York, NY 10024-5192;* [3] *Palaeontological Institute, Russian Academy of Sciences, Profsoyuznaya St. 123, Moscow 117997, Russia; Email: rasnaa@mail.ru;* [4] *Department of Palaeontology, The Natural History Museum, Cromwell Road, London SW7 5BD, UK*

The first fossil honey bee (Apini: *Apis* Linnaeus) from the New World is described and figured, expanding the former native range of the tribe Apini into the Western Hemisphere. *Apis nearctica* sp. nov., is represented by a single female worker preserved in paper shale from the Middle Miocene of Stewart Valley, Nevada. The species belongs to the *armbrusteri* species group (= *Cascapis* Engel) and is most similar to the extinct species *A. armbrusteri* Zeuner from the Miocene of southwestern Germany. The species is described and its affinities discussed, as well as its implications for our understanding of honey bee and corbiculate bee biogeography and evolution.

KEYWORDS: *Apis*, honey bees, Nearctic, Nevada, Tertiary, taxonomy, biogeography

The honey bees (Apini: *Apis* Linnaeus) are the most famous of all bees, and among the most familiar of all invertebrates, particularly the nearly ubiquitous western honey bee, *Apis mellifera* Linnaeus. This conspicuous lineage of social pollinators has had a long and intimate history with man, depicted in Late Paleolithic cave paintings such as Cuevas de la Araña of the Spanish Levant (near Valencia, Spain) in which men are portrayed collecting honey combs. Early religions of all variety sought inspiration from honey bees and venerated colonies for the sweet substance they produced. Not surprisingly, early on in human history domestication of *Apis* was achieved, usually housing the vertical, waxen combs within wooden boxes or more commonly cylinders made of clay or mud (e.g., Crane 1983, 1999). By the time of the Minoan Civilization there are documents in the ancient script "Linear B" of major honey stores indicative of significant beekeeping operations and honey trade, and Egyptian beekeeping operations are depicted on tomb paintings from even earlier eras, similarly within the ancient Near East such as Sumeria, Assyria, Babylonia, and the Hittite Kingdom centered at Bogazköy. Indeed, ancient Talmudic laws compiled by Jewish scribes during their captivity in Babylon ("The Exile", 597–539 B.C.) discuss topics ranging from the harvesting of honey on the Sabbath to the proper placement of hives in relation to human domiciles. Early man found that honey bees were not present in some regions, such as Australia, most Oceanic Islands (e.g., Micronesia, Polynesia), and the New World. For some cultures such isolation from the fruit of honey bee labors was of little consequence, but for nearly all of those who developed alongside one or more species of *Apis* this insulation was intolerable. Accordingly, nearly everywhere humans spread, domesticated colonies of honey bees shortly followed such that today species of *Apis*, particularly *A. mellifera*, can be found feral or domesticated in nearly any region of the World.

In 1622 the first hives of *A. mellifera mellifera* were introduced into the eastern United States, followed shortly thereafter by hives of *A. mellifera ligustica* Spinola and other subspecies. Early reports of honey bees in the Central American regions of the New World were based on misidentifications with stingless bees of the genus *Melipona* Illiger (e.g., Hernandez 1648), with authors of the era rightly noting that honey bees had been transported with colonists to the New World (Josselyn 1674). More than a century later this history apparently had been forgotten and debates began to rage over the nativity of honey bees in the Americas, with some authors considering the feral North American populations as specifically distinct from their native European counterparts (e.g., Belknap 1792) although most correctly recognized them as merely introduced (e.g., Barton 1793). Indeed, U.S. President Thomas Jefferson even noted in his *Notes on the State of Virginia* that the Native American populace referred to honey bees as the "white man's fly" and that this unfamiliar insect served as an advance signal of encroaching European settlements (Jefferson 1787). Despite the error of Belknap and some of his contemporaries regarding the nativity of *A. mellifera* in the nascent United States, these authors were unwittingly correct in believing the genus *Apis* to have been otherwise native in the Americas. Although all native records of living and fossil honey bees have hitherto come from Europe, Africa, or Asia, and all evolutionary hypotheses based strictly within this Old World framework (e.g., Ruttner 1988; Engel 1998), a recent discovery from the western United States dramatically rewrites the history of *Apis* and our understanding of honey bee biogeography. Herein we describe the first fossil honey bee from North America, the first of its tribe for the Western Hemisphere and allied to a species previously known from roughly contemporaneous deposits in southwestern Germany. All previous fossils of *Apis* have come from within the range of the modern species: either from the Oligocene-Miocene of Europe or the Miocene of Asia (Engel 1998, 1999, 2006), with Late Quaternary records of modern *A. mellifera* in East African copal (Zeuner and Manning 1976) and putative *A. cerana* combs in caves from Malaysia (Stauffer 1979). Lastly, we provide a brief overview of honey bee and corbiculate bee evolution and biogeography from the perspective of this revised geological history.

MATERIAL AND METHODS

The specimen described and discussed herein was recovered from the Late Barstovian (*ca.* 14–14.5 Ma) paper shales of the Stewart Valley Basin in west-central Nevada. A total of 117 Hymenoptera recovered from the site are in the California Academy of Sciences collection. Most are ants (Formicidae, 80 specimens), followed by ichneumonids (14), braconids (9), diapriids (7), and vespids (2), with single specimens of Proctotrupidae, Tiphiidae, Aculeata indeterminate, Parasitica indeterminate, and the *Apis* reported herein. Overall the hymenopteran diversity is consistent with other Neogene localities, and the large number of diapriids suggests a well forested environment.

Morphological terminology in the following descriptions follows that used elsewhere for bees (e.g., Engel 2001a; Michener 2007; Tan et al. 2008). The taxonomy of honey bees has been in flux for many years, with numerous superfluous synonyms and subspecific names (e.g., Engel 1999, with some updates provided by Engel 2003, 2006, unpubl. data; Radloff et al., in review) and anywhere from four to 24 species recognized in as many as three separate genera (e.g., Gerstäcker 1862, 1863; Smith 1865; Ashmead 1904; Buttel-Reepen 1906; Enderlein 1906; Skorikov 1929a, 1929b; Maa 1953; Ruttner 1988; Engel 1999). The system and characters used herein follows that of Engel (1998, 1999, 2006), which recognizes seven modern species (Fig. 1).

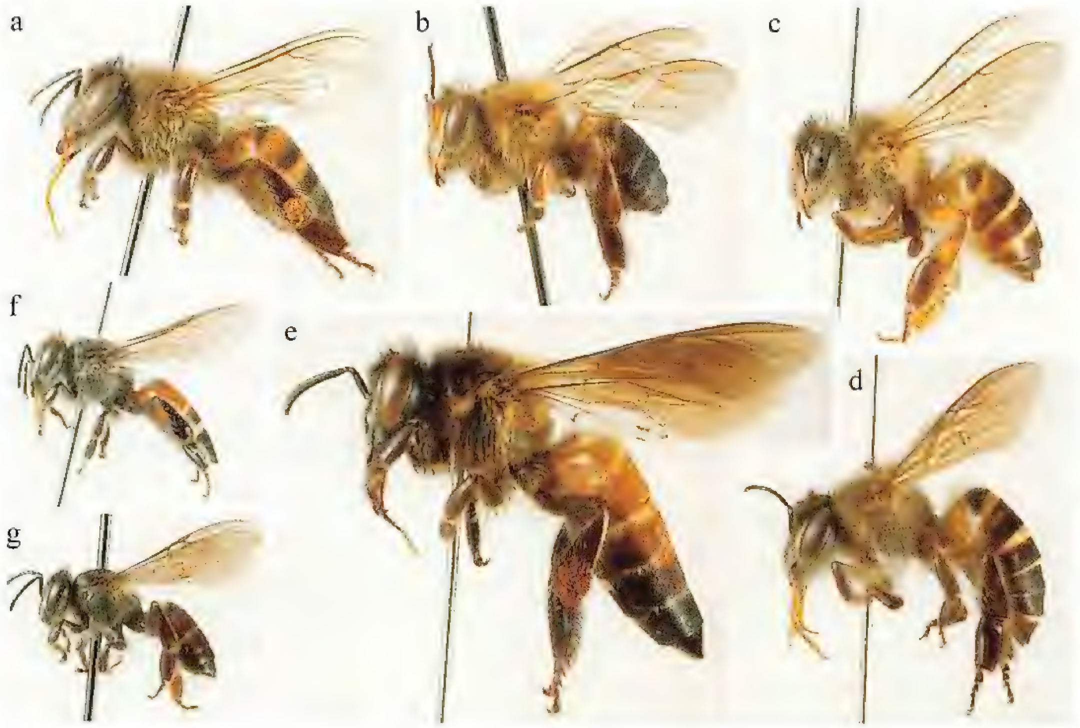


Figure 1. Modern honey bee diversity – a) *Apis* (*Apis*) *mellifera* Linnaeus; b) *A.* (*A.*) *koschevnikovi* Enderlein; c) *A.* (*A.*) *nigrocincta* Smith; d) *A.* (*A.*) *cerana* Fabricius; e) *A.* (*Megapis*) *dorsata* Fabricius; f) *A.* (*Micrapis*) *florea* Fabricius; g) *A.* (*M.*) *andreniformis* Smith. All specimens to same scale.

Systematic Paleontology

Tribe Apini Latreille
Genus *Apis* Linnaeus

Subgenus *Cascapis* Engel

Hauffapis Armbruster, 1938a: 37. *Nomen invalidum.*
Cascapis Engel, 1999: 187. Type species: *Apis armbrusteri* Zeuner, 1931, by original designation.

Diagnosis.— Honey bees of average size (forewing lengths about 9 mm, similar in proportion to modern *A. mellifera* or *A. cerana* Fabricius) with the derived condition of the basal vein distad cu-a by distance equivalent to about cu-a length or more, but retaining the ancestral condition of a relatively large third submarginal cell in which the anterior border (along the marginal cell) is wide and the posterior-apical angle is relatively broad (ranging from slightly so in the new species to more dramatically so in *A. armbrusteri*). The hind wing primitively possesses the distal abscissa of M (independently lost in *Micrapis* and *A. mellifera*).

Included species.— *Apis armbrusteri* Zeuner, 1931 (Miocene of Europe: Böttingen Marmors and Randecker Maars, Württemburg, southwestern Germany) and *A. nearctica* sp. nov. (Middle Miocene of North America: Stewart Valley, Mineral County, central western Nevada).

Key to Species of *Cascapis*

1. Metabasitarsus about 1.6 times as long as wide; mesoscutellum very light brown (perhaps reddish brown in life), contrasting with dark brown mesoscutum (Fig. 2); pleura light brown; labrum yellow; second free abscissa of Rs strongly arched [western North America, Middle Miocene] . . . . *A. nearctica* sp. nov.
Metabasitarsus about twice as long as wide (1.9–2.2 times as long as wide); mesoscutellum concolorous with mesoscutum (apparently dark brown); pleura dark brown; labrum dark brown; second free abscissa of Rs weakly curved or nearly straight [northern Europe, Early to Middle Miocene] . . . . *A. armbrusteri* Zeuner

Apis (*Cascapis*) *nearctica*, Engel, Hinojosa-Díaz, and Rasnitsyn, sp. nov.

Figures 2–6

Diagnosis.— Similar to *A. armbrusteri* but can be separated by the shorter metabasistarsus, the contrasting integumental coloration of the mesoscutum and mesoscutellum, the light brown pleura, the yellow labrum, and the strongly arched second free abscissa of Rs (a feature that also differs from many modern *Apis*) (*vide* Key, *supra*). The species can be further distinguished from all other honey bees by the apparent reduction of the supraclypeal area in which the antennal toruli abut the basal clypeal margin, without evidence of the short, subantennal sulci in modern *Apis* species (admittedly this condition has not been documented for other fossil honey bees and is not easily visible in the specimens of *A. armbrusteri* seen, it may also be the same condition, or at least similar, in *A. henshawi*). The hind wings of *A. nearctica* and *A. armbrusteri* are virtually identical.

Description.— **Female (worker).** Head length (as measured from top of vertex to median clypeal apex) 3.38 mm, head width 3.33 mm; scape length 1.48 mm; mandible length 1.33 mm, apical width 0.54 mm; mesoscutal length 3.00 mm, width 2.75 mm; mesoscutellar length 0.67 mm; forewing length (as preserved, apicalmost portion missing) 7.83 mm (perhaps 9.0–9.2 mm in total length in life), maximum preserved width 2.83 mm; hind wing length (as preserved, apicalmost portion missing) 4.17 mm; mesobasitarsus length 1.58 mm, width 0.75 mm; metatibia (corbicula) length 2.88 mm, maximal width 1.08 mm; metabasitarsus length 2.08 mm, width 1.25 mm; first metasomal tergum length 1.75 mm, width 4.00 mm (perhaps distorted from being flattened as it appears somewhat outstretched). Head slightly longer than wide, dark brown except as indicated; scape elongate and dark brown; malar space elongate, nearly as long as clypeal medial length; antennal toruli apparently abutting clypeal basal margin. Compound eyes oblong, with inner margin concave, densely covered in elongate setae (most easily visible under thin layer of distilled water to increase contrast). Clypeus broader than long, widest at tangent of mandibular articulation, apical margin gently concave, dark brown in color. Labrum much broader than long, apical margin gently concave, yellow in color (Figs. 3a, 5a). Mandible spatulate (with broad basal articulation, narrow mid-region, and apically expanded distal third), margins obliquely truncate, without dentition, inner surface with evident median and posterior keels (*sensu* Maa 1953) (Figs. 3b, 5b), outer surface apparently without sculpturing; basal half brown, apical half yellow. Pleura apparently light brown; mesoscutum dark brown, contrasting with relatively bulbous and light brown mesoscutellum; metanotum and propodeum not evident. Legs light brown; metatibia with corbicula developed on outer surface (corbicula *sensu* Engel 2001a, not the broader concept of Michener 1999), with well-defined rastellum present (rastellar comb setae on inner apical margin of metatibia evident in dorsal view extending beyond apex) (Figs. 4c, 5c), apical spurs absent; metabasitarsus with well-defined auricle present on basal margin (Figs. 4b, 5d), at least four pollen brush rows evident on inner surface (Fig. 5d), metabasitarsus about 1.6 times as long as wide, about 0.72 times length of

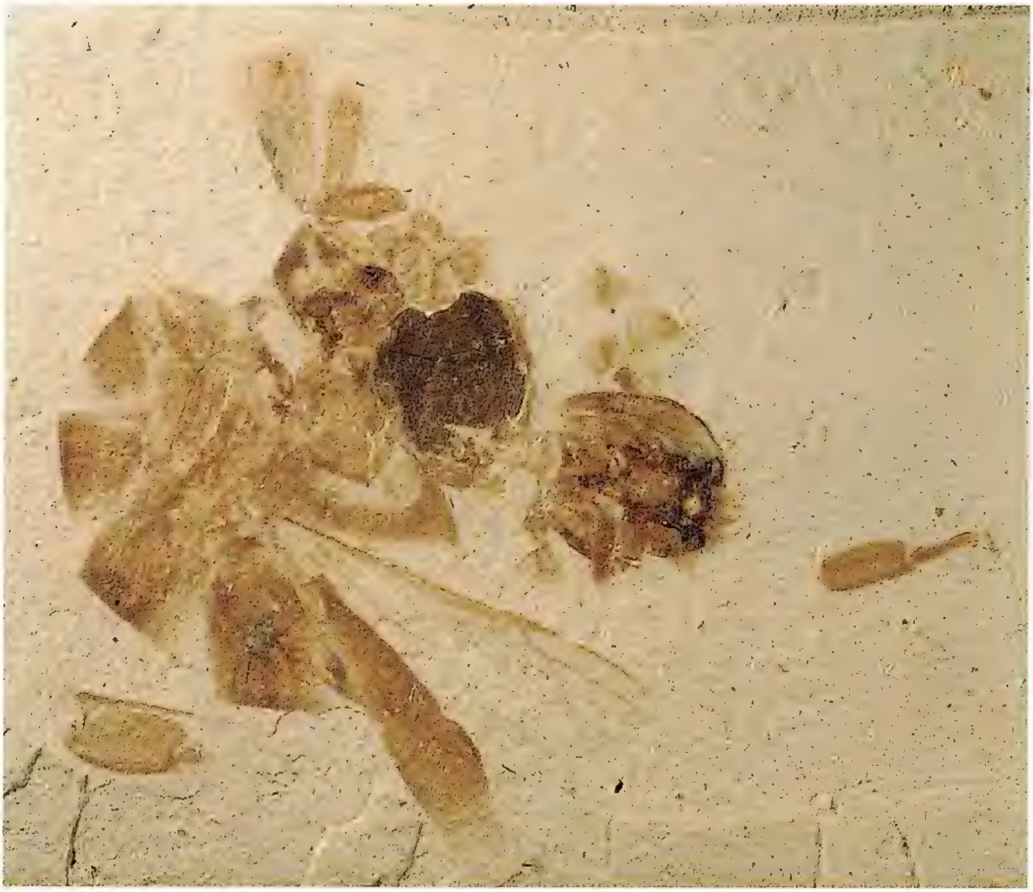


FIGURE 2. Holotype worker of *Apis* (*Cascapis*) *nearctica* sp. nov. (CAS #236) as preserved.

metatibia (*versus* about twice as long as wide and 0.67 times length of metatibia in *A. armbrusteri*); pretarsal ungues stout, simple; arolium present and large (Fig. 4a). Metasoma typical for worker honey bee; apical margins of terga relatively straight, terga uniformly colored and brown except medioapical surface of first metasomal tergum lighter and apparently slightly concave; sting evident and straight, with at least a few distinct barbs or serrations along one lancet (Fig. 5e). Forewing with venation typical of *Apis* and subgenus *Cascapis*; basal vein separated from 1cu-a by distance nearly equivalent to 1cu-a length; first submarginal cell smallest, with first free abscissa Rs sinuate (rather than relatively straight); r-rs shorter than anterior margin of second submarginal cell; second submarginal cell trapezoidal in overall shape, with 1rs-m relatively straight and strongly slanted apically such that posterior border of cell is slightly more than three times length of anterior border; third submarginal cell relatively broad anteriorly, with 2rs-m relatively straight for nearly its entirely length before distinctly curving to meet M (Figs. 3, 6), lacking aRs$_2$ (*sensu* Tan et al. 2008). Hind wing with typical *Apis* venation, with distal abscissa M present (Fig. 6).

HOLOTYPE.— Female (worker); #236, USA: Nevada, Mineral County, Stewart Valley, Cal State Site, UTMG [Universal Transverse Mercator Grid]: Zone 11, ^{4}18.170 E × ^{42}71.640 N, 38°35′29″N × 117°56′24″W, Middle Miocene, Late Barstovian (ca. 14–14.5 Ma) paper shales; deposited in the Department of Entomology, California Academy of Sciences, San Francisco, California.

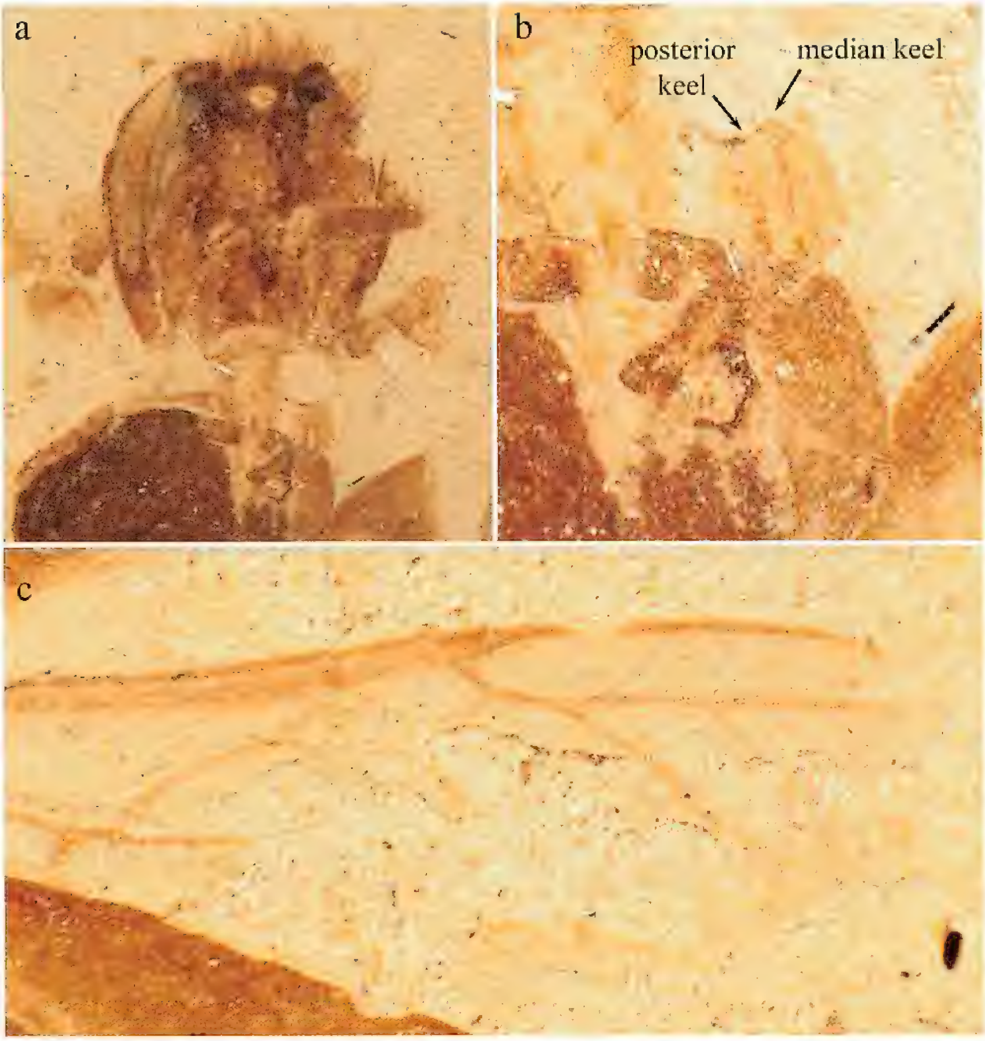


FIGURE 3. Details of holotype worker of *Apis* (*Cascapis*) *nearctica* sp. nov. (CAS #236) – a) head; b) detail of right mandible; c) forewing.

ETYMOLOGY.— The specific epithet is based on the native geographic location of the species in the Nearctic region.

REMARKS.— Although the bee itself is largely disarticulated (Fig. 2), the structures are preserved with remarkable fidelity and nearly every sclerite can be found on the small slab. The head has become entirely dislodged from the body, with the right antenna missing and the left preserved only by the scape. The mandibles have been pulled widely open and the right has become disarticulated and lies partly overlapping the mesosoma (Fig. 3b). The left mandible is twisted in position but remains somewhat attached to the head capsule but is directed upward and away at an oblique angle (Fig. 3a). The labiomaxillary complex is partly extended. The mesosoma can only be seen in dorsal aspect and is directed away from the head such that the right mandible and apex of the glossa overlap the enlarged mesoscutellum and the posterior border of the mesoscutum. The left tegula can be discerned but the other is apparently missing. The pronotum can only be barely seen and the metanotum and propodeum are entirely obscured from view by the mesoscutellum. Some dam-

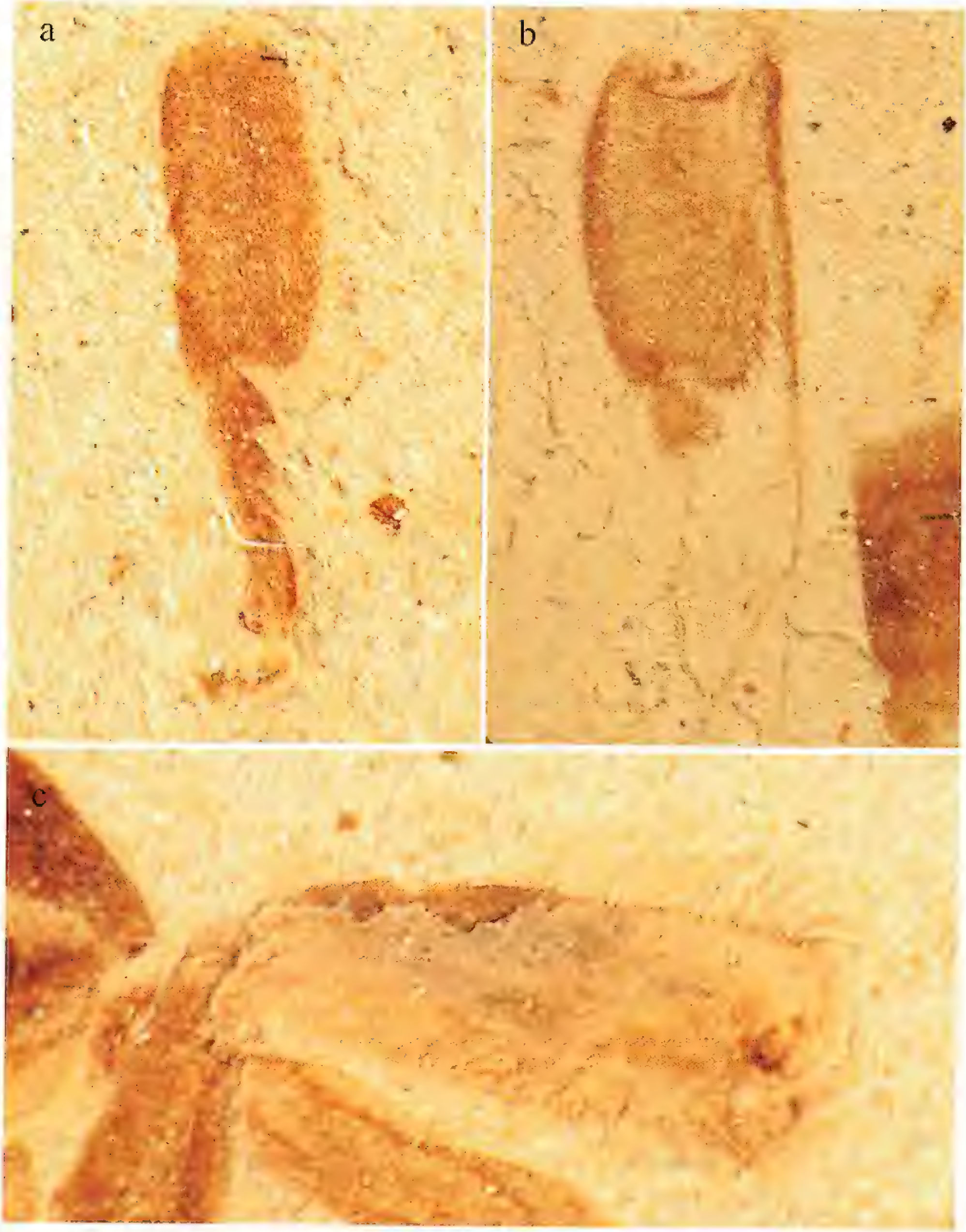


FIGURE 4. Details of holotype worker of *Apis* (*Cascapis*) *nearctica* sp. nov. (CAS #236) – a) mesotarsus and meso-pretarsus; b) metabasitarsus and first article of metamediotarsus, portion of hind wing can be seen preserved beneath the metabasitarus; c) corbicula.

aged sclerites that are difficult to interpret to the left of the mesosoma may represent fragments of pleural sclerites. The abdomen is entirely exploded with the dorsal and anterior-facing surfaces of the first metasomal tergum slightly offset to the left of the posterior of the mesosoma (Fig. 2). The remainder of the abdomen is twisted in lateral position and pulled away from the first metasomal segment, while simultaneously twisted back anteriorly such that the successive segments curl back

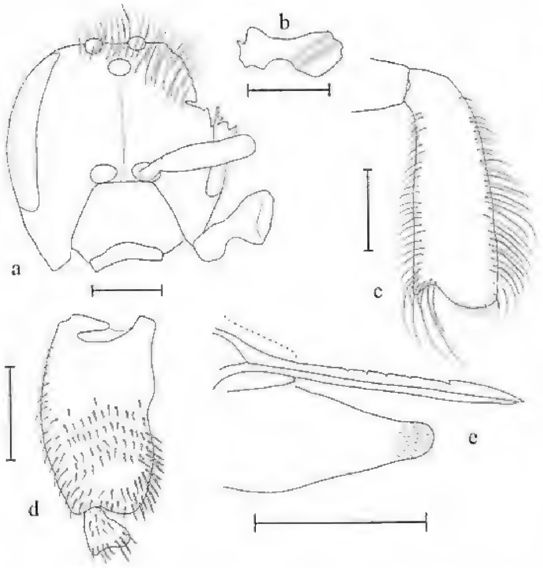


FIGURE 5. Line illustrations of holotype worker of *Apis* (*Cascapis*) *nearctica* sp. nov. (CAS #236) – a) head and left mandible; b) right mandible; c) metabasitarsus; d) corbicula; e) sting. Scale bars = 1 mm.

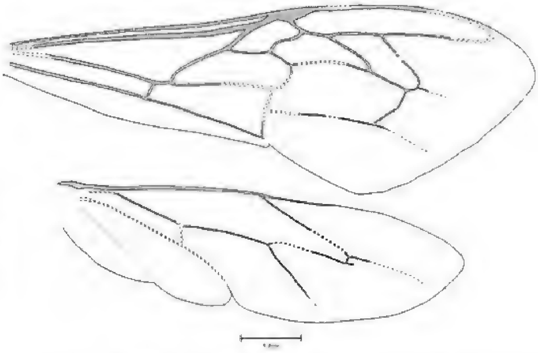


FIGURE 6. Wing venation of *Apis* (*Cascapis*) *nearctica* sp. nov. (CAS #236); forewing above, hind wing below.

toward the anterior of the mesosoma (Fig. 2). The sting is faintly preserved but can be discerned at the apex of the abdominal sclerites. Legs components are scattered over the slab as are the wings. A relatively complete forewing lies between the first metasomal tergum and the second abdominal segment (Figs. 2, 3c), while a hind wing, very faintly impressed, is preserved in line with, and partly underneath, an isolated metabasitarsus and second metatarsomere alongside the second and third abdominal segments (Figs. 2, 4b). A metatibia and metafemur lie disarticulated alongside the anterior of the mesosoma (Figs. 2, 4c). Other leg fragments lay further away from the concentration of body components (e.g., Fig. 4a). All in all, the specimen is remarkably complete, albeit not in one piece nor as the bee clearly functioned in life.

The third submarginal cell is a bit more elongate posteriorly in *A. nearctica* than that seen in *A. armbrusteri*, resulting in 2rs-m being distinctly arched at its posterior-apical corner, while this is very weakly curved in the latter species. This might indicate more affinity with the crown-group honey bees, but in the absence of more corroborating characters we cannot definitively place *A. nearctica* closer to the *Micrapis* + *Megapis* + *Apis s.str*. clade and have accordingly retained it within *Cascapis*.

Apis (*Cascapis*) *armbrusteri* Zeuner

Apis armbrusteri Zeuner, 1931:292; Statz, 1934:7; Armbruster, 1938a:12, 45; Statz, 1941:102; Roussy, 1937:65; Statz, 1944:65; Maa, 1953:631, 633; Kelner-Pillault, 1969a:89; Kelner-Pillault, 1969b:525; Zeuner and Manning, 1976:244; Culliney, 1983:34; Ruttner et al., 1986:348–350; Ruttner, 1988:26–30; Zhang, 1990:87; Petrov, 1992:361; Ruttner, 1992:138–140; Michener, 1990:140; Hong and Miao, 1992:2; Lutz, 1993:183–184, 188, 191, 192; Michener, 1997:28; Engel, 1998:266, 276–279; Engel, 1999:187; Nel et al., 1999:261; Engel, 2000:224; Michener, 2000:807; Engel, 2001b:115; Engel, 2002:5; Kotthoff, 2005:4, 17–18, 24–25; Engel, 2006:3, 6, 7; Michener, 2007:831; Tan et al., 2008:680.

Hauffapis scheuthlei Armbruster, 1938a:43; Maa, 1953:632; Culliney, 1983:34.

Hauffapis scheeri Armbruster, 1938a:43; Maa, 1953:632; Culliney, 1983:34.

Hauffapis scharmanni Armbruster, 1938a:44; Maa, 1953:632; Culliney, 1983:34.

Hauffapis scheeri variety *gallauni* Armbruster, 1938a:45; Maa, 1953:632.

Hauffapis scheeri variety *rahdei* Armbruster, 1938a:45; Maa, 1953:632.

Hauffapis scheuthlei variety *seemanni* Armbruster, 1938a:45; Maa, 1953:632.

Hauffapis scheuthlei variety *zeuneri* Armbruster, 1938a:45; Maa, 1953:632.

Apis (*Apis*) *armbrusteri armbrusteri* Zeuner; Zeuner and Manning, 1976:245; Burnham, 1978:123; Culliney, 1983:34; Zhang, 1990:87; Hong and Miao, 1992:2; Nel et al., 1999:261.

Apis (*Apis*) *armbrusteri scharmanni* (Armbruster); Zeuner and Manning, 1976:246; Burnham, 1978:123; Culliney, 1983:34; Zhang, 1990:88; Hong and Miao, 1992:2; Nel et al., 1999:261.

Apis (*Apis*) *armbrusteri scheeri* (Armbruster); Zeuner and Manning, 1976:247; Burnham, 1978:123; Culliney, 1983:34; Zhang, 1990:88; Hong and Miao, 1992:2; Nel et al., 1999:261.

Apis (*Apis*) *armbrusteri scheuthlei* (Armbruster); Zeuner and Manning, 1976:247; Burnham, 1978:123; Culliney, 1983:34; Zhang, 1990:88; Nel et al., 1999:261.

Apis armbrusteri cheuthlei Hong and Miao, 1992:2. *Lapsus calami*.

Apis scheeri (Armbruster); Schweigert and Bechly, 2001:4.

Apis scheuthlei (Armbruster); Schweigert and Bechly, 2001:4.

Apis scharmanni (Armbruster); Schweigert and Bechly, 2001:4.

DIAGNOSIS.— Refer to key and diagnosis for *A. nearctica* (*vide supra*).

REMARKS.— *Apis armbrusteri* was described by Frederick E. Zeuner (1931) based on a "swarm" of worker bees preserved on a slab of thermal limestone from near Böttingen in the Swabian Alb, Württemburg, Germany. This area bordered a Miocene volcanic crater and which apparently had hot springs formed within fissures releasing carbon dioxide, into which the bees had apparently fallen and perished. In the same area and time period of Württemberg was a somewhat larger crater which formed a lake, the Randecker Maar. Shales of the Randecker Maar have preserved a wide diversity of fossils, including an abundance of insects (e.g., Schweigert and Bechly 2001; Kotthoff 2005). Wilhelm Scheuthle initially discovered bees at the Randecker Maar in 1926 and was joined in the hunt for more by Ludwig Armbruster in 1928. A large number of specimens were accumulated and in 1938 Armbruster published an account of their material, describing three separate species and several subspecies for each minor variation in size and shape which they had discovered such that nearly everyone who participated in their digs was honored with a patronym. The variation described by Armbruster (1938a, 1938b, 1938c) certainly falls well within the range seen within modern honey bee species (sometimes even within a single population or colony!) and there can be no justification for the fine distinctions Armbruster drew for recognizing so many, nearly identical species from an area of less than 50 square miles (including the Böttingen material and locality). Unfortunately, Armbruster's account of the honey bees from Randecker Maar is fraught with errors and cannot be relied upon. Despite the assertions of Zeuner (1931) and Armbruster (1938a, 1938b, 1938c), unfortunately perpetuated by Maa (1953), the compound eyes are not bare, the mouthparts are not weakly developed, and the mesoscutum does not overlap the mesoscutellum. Zeuner and Manning (1976) rightly synonymized the various species of Armbruster but unfortunately retained some of his taxa as subspecies. These were later synonymized by Engel (1999). The Lower Miocene *Apis* from the Most Basin, Czech Republic reported by Prokop and Nel (2003) appears to be a specimen of *A. armbrusteri*, as do "species" D, E, F, and H of Nel et al. (1999).

DISCUSSION

Honey bees comprise one of four remarkably apomorphic, living tribes of corbiculate apine bees (Engel 2001a; Michener 2007), the others being the highly eusocial Meliponini (stingless bees), the primitively eusocial Bombini (bumble bees), and the communal or solitary Euglossini (orchid bees). A further three tribes — Melikertini, Electrapini, and Electrobombini — are known only from as recently as the Eocene (Engel 2001a). Apini are most closely related to the stingless bees (Meliponini) and melikertine bees (Engel 2001a; Schultz et al. 1999, 2001; Cardinal and Packer 2007). Like each of the corbiculate tribes, numerous apomorphies support the monophyly of Apini and nearly all of those observable in the worker caste are readily visible in the fossil discussed herein — compound eye covered in dense, long setae; worker mandible lacking dentition; metatibia without spurs or penicillum; inner surface of metabasitarsus with brush combs rows of setae; forewing marginal cell elongate, with rounded apex set off from wing margin, 1rs-m and 2rs-m strongly angled respective to M; sting straight and barbed. Thus, despite the overall fragmentary nature of the specimen, a remarkable diversity of features are finely preserved permitting a confident attribution of the specimen not only to genus but permitting diagnosis of the species. Nonetheless, it is greatly hoped that further and more complete, or at least fully articulated, specimens will be recovered in time. Among living *Apis* the wing venation of the giant honey bees (*Megapis* Ashmead) retain the most plesiomorphies, hence it is little wonder why the venation of *A. dorsata* Fabricius and *A. lithohermaea* Engel are reminiscent in some respects to those of *A. armbrusteri* and *A. nearctica* in regard to the width of the anterior border of the third submarginal cell in the forewing and the presence of the distal abscissa of M in the hind wing.

TABLE 1: Classification of living and fossil honey bees (Apini: *Apis*).

- —Tribe APINI Latreille—
- Genus *Apis* Linnaeus (*s. lato*)
  - henshawi species group (†*Priorapis* Engel, †*Synapis* Cockerell)
    - †*A. vetusta* Engel
    - †*A. henshawi* Cockerell
    - †*A. petrefacta* (Říha)
    - †*A. miocenica* Hong
    - †*A. "longtibia"* Zhang
    - †*A.* "Miocene 1"
  - armbrusteri species group (†*Cascapis* Engel)
    - †*A. armbrusteri* Zeuner
    - †*A. nearctica*, sp. nov.
  - florea species group (*Micrapis* Ashmead)
    - *A. florea* Fabricius
    - *A. andreniformis* Smith
  - dorsata species group (*Megapis* Ashmead)
    - †*A. lithohermaea* Engel
    - *A. dorsata* Fabricius
  - mellifera species group (*Apis* Linnaeus *s. stricto*)
    - mellifera subgroup
      - *A. mellifera* Linnaeus (*Apis* Linnaeus *s. strictissimo*)
    - cerana subgroup (*Sigmatapis* Maa)
      - *A. cerana* Fabricius
      - *A. nigrocincta* Smith
      - *A. koschevnikovi* Enderlein

The presence of *Apis* in North America during the Tertiary highlights the futility of building historical biogeographic hypotheses in the absence of a fossil record (Rasnitsyn 2006). The vast majority of life is extinct and to surmise that we have adequately sampled a group when looking only at modern members is naïve, even in the absence of a fossil record for that particular lineage. Every taxon or clade represents an unbroken genetic lineage back through time and what we have seen in every group with a preserved record is that there have been false starts and evolutionary experimentations that eventually gave rise to the modern diversity. Some of these fossils are intercalated among the crown or surviving species of a clade, while others form grades (stem groups) or natural sister groups to a lineage otherwise characterized on the basis of a suite of attributes seen in crown-group taxa. Changing historical environments, abiotic historical events, or even past differences in biology may result in fossil species that do not occur in the same region or habitat in which modern counterparts live. Fossil insects have redefined biogeographic hypotheses of various lineages of insects otherwise believed to have modern restricted distributions resulting from various vicariant events (e.g., Rasnitsyn 2006; Grimaldi and Engel 2005, 2006; Engel 2008; Engel and Grimaldi 2007, 2008; Engel et al. 2007; Azar and Engel 2008). Elaborate hypotheses have been constructed for the tribes of corbiculate bees, as well as many other insect lineages, that *a priori* assume that the current absence of a group from a particular region today means that this group or its predecessors (stem groups) was similarly not present in that same geographical region. Such biogeographic hypotheses have even been used to argue against certain phylogenetic reconstructions that seem otherwise at odds with vicariant models based solely on surviving species. Relationships among the four extant corbiculate tribes (Apini, Bombini, Euglossini and Meliponini) have been examined recurrently in the last three decades. Studies using different sets of characters; either morphological, molecular, behavioral, or combined; have produced nine of the 15 theoretically possible rooted and fully resolved topologies, as noted by Cardinal and Packer (2007), who present a summary of these different hypotheses. The difficulty of analyzing relationships among the corbiculate tribes can be immediately appreciated by this over abundance of purportedly supported hypotheses. Nonetheless, the main point of contention seems to lie between a hypothesis supported by morphological (Prentice 1991; Roig-Alsina and Michener 1993; Schultz et al. 1999, 2001; Engel 2001a, 2001c; Cardinal and Packer 2007), behavioral (Noll 2002), and combined morphological-molecular (e.g., Ascher et al. 2001) studies, in which Euglossini are sister to the other tribes (Euglossini + (Bombini + (Apini + Meliponini))), and several strictly molecular approaches (Cameron 1991, 1993; Mardulyn and Cameron 1999; Cameron and Mardulyn 2001) which produce a sister-group relationship between Bombini and Meliponini. Interestingly enough, of the two cases mentioned, the first hypothesis (Euglossini sister to the other extant tribes, while Apini sister to Meliponini) is strongly supported in studies in which fossil corbiculates are included (Engel 2001a, 2001c), with the addition of three extinct tribes (Euglossini + (Bombini + (Electrobombini + (Electrapini + (Apini + (Meliponini + Melikertini)))))). The current evidence seems to favor strongly this phylogenetic arrangement, as proposed for most of the morphology-based studies. On the other hand, the distribution of the living representatives of the extant corbiculate tribes gives a picture that is not necessarily easily explained by this phylogenetic hypothesis. The Euglossini are restricted to the Neotropical region, while the Bombini are primarily Palearctic (but also Nearctic, Neotropical, and Oriental in distribution), the Apini are Palearctic, Ethiopian, and Oriental, and the Meliponini are Pantropical (e.g., Rebêlo 2001; Michener 2007). As such the restriction of the Euglossini (sister to the reminder of the tribes) to the New World tropics seems to be at odds with a basal placement in the clade. Rebêlo (2001) concluded that if Euglossini and Bombini shared an immediate common ancestor (i.e., were sisters), then this ancestral population likely existed across a combined supercontinent ("Pangea" in his scenario, although true Pangea predated any of these lineages). He further speculated that during the separation of the Northern Hemisphere and Southern Hemisphere vicariant populations were produced, the northern one ancestral to the Bombini and the southern one to Euglossini, so the absence of the latter from other Gondwanan continents (at least from Africa) could imply that they perhaps existed there with subsequent extinction. It should be noted, however, that the initial rifting of these continental plates began much earlier than the time frame by which Rebêlo (2001) speculated making his scenario a less than ideal match. Regardless, the same author (Rebêlo 2001) as well as Michener (2007), interpreted the modern distribution of Euglossini as the result origination in South America after the complete separation of this continent from Africa (around 100 mya), and evolving there. In any case the interpretation of Euglossini existing once in Africa and going extinct, or never existing there at all, is largely hindered by a lack of suitable paleontological information from that region. That crown group Euglossini date from the Paleocene or earlier, with numerous extinct stem groups of widespread distribution, is certainly a distinct possibility. This also indicates that molecular estimates based strictly on modern (i.e., crown group) euglossines would not be capable of successfully estimating the age at which the lineage (stem and crown groups together) diverged from other corbiculates but instead only when the crown group first appeared, which would be much later. Regardless, paleontological discoveries such as the "lost" corbiculate tribes and of Apini in the Nearctic region demonstrate that significant losses in corbiculate diversity have taken place. Attempts to overlap biogeographical information based exclusively on modern species may contradict well supported phylogenies, but at the same time must be taken with extreme caution as extinction is a real and significant factor that is frequently ignored in cladistic biogeographic analyses (Rasnitsyn 2006).

In terms of *Apis* distribution, biotic exchanges between Asia and North America via Beringia are known from the Late Cretaceous and Miocene periods (e.g., Hopkins 1967; Kontrimavichus 1985), well before the more famously studied Pleistocene connection that permitted early humans to disperse into the Americas. It is likely that species of *Cascapis* were widespread across Europe and Asia during the Early and mid-Miocene, perhaps even the latest Oligocene, and were capable of dispersing into western North America like so many other plant and animal species of the time. The closing of this passageway during the latter part of the Miocene would have left species such as *A. nearctica* isolated and the eventual climatic changes that took place later in and by the close of the Miocene, dramatically altering the flora and fauna of Neogene western North America potentially resulting in their demise at that time. Continued climate change from warm-wet to cool-dry conditions following the mid-Miocene may have contributed to an eventual demise of honey bees in northwestern North America, similar to that seen in some mammal and plant groups (Kürschner et al. 2008).

Honey bees are aggressive competitors of stingless bee colonies wherever they are sympatric. Indeed, it has been noted that stingless bee diversity is greatest in regions where honey bees are not native (e.g., meliponine diversity is greatest in South and Central America, but relatively poor in tropical Africa and Asia), and it is likely that this competitive behavior has contributed to the overall shape of meliponine diversity as well as the overall loss of eusocial bee diversity since the Eocene. Expanding the native distribution of Apini into the New World would appear to contradict some details of this observed pattern in that it would appear little would exclude *Apis* from having co-occurred with the radiation of Meliponini in South America during the Tertiary. However, Miocene climate and habitat might indicate that *Apis* was perhaps relatively confined within North America and that the aforementioned scenario for meliponine diversification might remain viable. During the Early Miocene, western North America beyond the Sierras was of a tropical to warm temperate climate, similar to much of the Palearctic during the same period (e.g., Retallack 2004). This region was bounded by a large, strongly arid area running from central Mexico through the center of the United States, effectively representing a major habitat barrier for honey bees. It is likely that while species of *Cascapis* were contiguous from Europe, northern Asia, and the westernmost North America (perhaps only northwestern North America), honey bees were prevented from migrating further in the Americas and from reaching other New World tropical regions like South America. This would have resulted in a natural absence of Apini from the region in which Meliponini experienced its greatest diversification.

Honey bees were likely truly absent from the North American fauna during the Pliocene and Pleistocene, not becoming reintroduced until the major European colonization of the New World in the early 17th century. Certainly extensive exploration of further Miocene and Pliocene deposits must be undertaken in order to further document the extent of *Apis* distribution in North America and to help refine our estimates of when they declined and eventually disappeared from the fauna. Nonetheless, the currently available information on similar faunistic changes in Miocene North America and Neogene biogeography are consistent with the presence of honey bees in the region at that time and their extirpation late in the Miocene or earliest Pliocene at the latest. Regardless, *A. nearctica* highlights how the perceived absence of lineages from major geographic regions must be tempered with evidence from the fossil record. In the case of the honey bees, *A. nearctica* indicates that North America was one of the native regions of *Apis* distribution, where they became extinct sometime subsequent to the Miocene, and the genus, like horses (*Equus caballus* Linnaeus), gingkos, and the Chinese tree of heaven (*Ailanthus*), was later reintroduced by European colonization of the Americas.

ACKNOWLEDGMENTS

We are grateful to W.J. Pulawski for bringing the collection to our attention and permitting its study, and to C.D. Michener, K.K. Magill, O.R. Taylor, and an anonymous reviewer for encouragement and comments on earlier versions of the manuscript. Partial support was provided by National Science Foundation grants EF-0341724 and DEB-0542909 to M.S. Engel, while I.A. Hinojosa-Díaz was sponsored by CONACYT (Consejo Nacional de Ciencia y Tecnología, México). This is a contribution of the Division of Entomology (Paleoentomology), University of Kansas Natural History Museum.

LITERATURE CITED

ARMBRUSTER, L. 1938a. Versteinerte Honigbienen aus dem obermiocänen Randecker Maar. *Archiv für Bienenkunde* 19(1):1–48.

ARMBRUSTER, L. 1938b. Versteinerte Honigbienen aus dem obermiocänen Randecker Maar. *Archiv für Bienenkunde* 19(2):73–93.

ARMBRUSTER, L. 1938c. Versteinerte Honigbienen aus dem obermiocänen Randecker Maar. *Archiv für Bienenkunde* 19(3–4):97–133.

ASCHER, J.S., B.N. DANFORTH, AND S. JI. 2001. Phylogenetic utility of the major opsin in bees (Hymenoptera: Apoidea): A reassessment. *Molecular Phylogenetics and Evolution* 19(1):76–93.

ASHMEAD, W.H. 1904. Remarks on honey bees. *Proceedings of the Entomological Society of Washington* 6:120–122.

AZAR, D., AND M.S. ENGEL. 2008. A sphaeropsocid bark louse in Late Cretaceous amber from Siberia (Psocoptera: Sphaeropsocidae). *Transactions of the Kansas Academy of Science* 111(1–2):141–146.

BARTON, B.S. 1793. An inquiry into the question, whether the *Apis mellifica*, or true Honey-bee, is a native of America. *Transactions of the American Philosophical Society, Philadelphia* 3:241–261.

BELKNAP, J. 1792. *A Discourse Intended to Commemorate the Discovery of America by Christopher Columbus; Delivered at the Request of the Historical Society in Massachusetts, on the 23d Day of October, 1792, being the Completion of the Third Century since that Memorable Event. To which are added Four Dissertations, connected with various Parts of the Discourse.* Apollo, Belknap & Hall, Boston, Massachusetts, USA. 132 pp.

BURNHAM, L. 1978. Survey of social insects in the fossil record. *Psyche* 85(1):85–133.

BUTTEL-REEPEN, H., VON. 1906. Apistica. Beiträge zur Systematik, Biologie, sowie zur geschichtlichen und geographischen Verbreitung der Honigbiene (*Apis mellifica* L.), ihrer Varietäten und der übrigen *Apis*-Arten. *Mitteilungen aus dem Zoologischen Museum im Berlin* 3:117–201.

CAMERON, S.A. 1991. A new tribal phylogeny of the Apidae inferred from mitochondrial DNA sequences. Pages 71–87 *in* D.R. Smith, ed., *Diversity in the Genus* Apis. Westview Press, Boulder, Colorado.

CAMERON, S.A. 1993. Multiple origins of advanced eusociality in bees inferred from mitochondrial DNA sequences. *Proceedings of the National Academy of Sciences, U.S.A.* 90(18):8687–8691.

CAMERON, S.A., AND P. MARDULYN. 2001. Multiple molecular data sets suggest independent origins of highly eusocial behaviour in bees (Hymenoptera: Apinae). *Systematic Biology* 50(2):194–214.

CARDINAL, S., AND L. PACKER. 2007. Phylogenetic analysis of the corbiculate Apinae based on morphology of the sting apparatus (Hymenoptera: Apidae). *Cladistics* 23(2):99–118.

CRANE, E. 1983. *The Archaeology of Beekeeping*. Cornell University Press, Ithaca, New York, USA. 360 pp.

CRANE, E. 1999. *The World History of Beekeeping and Honey Hunting*. Routledge, New York, New York, USA. xxii + 682 pp.

Culliney, T.W. 1983. Origin and evolutionary history of the honeybees *Apis*. *Bee World* 64(1):29–38.

Enderlein, G. 1906. Neue Honigbienen und Beiträge zur Kenntnis der Verbreitung der Gattung *Apis*. *Stettiner Entomologische Zeitung* 67:331–344.

Engel, M.S. 1998. Fossil honey bees and evolution in the genus *Apis* (Hymenoptera: Apidae). *Apidologie* 29(3):265–281.

Engel, M.S. 1999. The taxonomy of Recent and fossil honey bees (Hymenoptera: Apidae; *Apis*). *Journal of Hymenoptera Research* 8(2):165–196.

Engel, M.S. 2000. Fossils and phylogeny: A paleontological perspective on social bee evolution. Pages 217–224 *in* M.M.G. Bitondi and K. Hartfelder, eds., *Anais do IV Encontro sobre Abelhas*. Universidade de São Paulo, Ribeirão Preto, Brazil.

Engel, M.S. 2001a. A monograph of the Baltic amber bees and evolution of the Apoidea (Hymenoptera). *Bulletin of the American Museum of Natural History* 259:1–192.

Engel, M.S. 2001b. The honey bees of Thailand (Hymenoptera: Apidae). *Natural History Bulletin of the Siam Society* 49:113–116.

Engel, M.S. 2001c. Monophyly and extensive extinction of advanced eusocial bees: Insights from an unexpected Eocene diversity. *Proceedings of the National Academy of Sciences, U.S.A.* 98(4):1661–1664.

Engel, M.S. 2002. The honey bees of India, Hymenoptera: Apidae. *Journal of the Bombay Natural History Society* 99(1):3–7.

Engel, M.S. 2003. A replacement name in *Apis* (Hymenoptera: Apidae). *Journal of the Kansas Entomological Society* 76(1):71.

Engel, M.S. 2006. A giant honey bee from the middle Miocene of Japan (Hymenoptera: Apidae). *American Museum Novitates* 3504:1–12.

Engel, M.S. 2008. An orussid wood wasp in amber from the Dominican Republic (Hymenoptera: Orussidae). *Transactions of the Kansas Academy of Science* 111(1–2):39–44.

Engel, M.S., and D.A. Grimaldi. 2007. Cretaceous Scolebythidae and phylogeny of the family (Hymenoptera: Chrysidoidea). *American Museum Novitates* 3568:1–16.

Engel, M.S., and D.A. Grimaldi. 2008. Diverse Neuropterida in Cretaceous amber, with particular reference to the paleofauna of Myanmar (Insecta). *Nova Supplementa Entomologica* 20:1–86.

Engel, M.S., D.A. Grimaldi, and K. Krishna. 2007. A synopsis of Baltic amber termites (Isoptera). *Stuttgarter Beiträge zur Naturkunde, Serie B, Geologie und Paläontologie* 372:1–20.

Gerstäcker, C.E.A. 1862. *Über die geographische Verbreitung und die Abänderungen der Honigbiene nebst Bemerkungen über die ausländischen Honigbienen der alten Welt*. Festschrift XI Wander-Versammlung deutscher Bienenwirthe, Potsdam, Germany. 75 pp.

Gerstäcker, C.E.A. 1863. On the geographical distribution and varieties of the honey-bee, with remarks upon the exotic honey-bees of the Old World. *Annals and Magazine of Natural History*, ser. 3, 11: 270–283, 333–347. [English translation of Gerstäcker (1862)]

Grimaldi, D., and M.S. Engel. 2005. *Evolution of the Insects*. Cambridge University Press, Cambridge, United Kingdom. xv + 755 pp.

Grimaldi, D., and M.S. Engel. 2006. Extralimital fossils of the "Gondwanan" family Sphaeropsocidae (Insecta: Psocodea). *American Museum Novitates* 3523:1–18.

Hernandez, F. 1648. *Rerum Medicarum Novae Hispaniae Thesaurus: Nova Plantarum, Animalium et Mineralium Historia*. Vitalis Mascardi, Romae [Rome], Italy. 950 + [10] + [90] + [6] pp.

Hong, Y.-C., and S.-J. Miao. 1992. Fossil bee [sic] and its origin with discussion on the origin of the angiosperm. *Memoirs of the Beijing Natural History Museum* 51:1–19. [In Chinese, with English summary]

Hopkins, D.M. 1967. *The Bering Land Bridge*. Stanford University Press, Stanford, California, xiii+495 pp.

Jefferson, T. 1787. *Notes on the State of Virginia*. Stockdale, London, United Kingdom. 382 pp.

Josselyn, J. 1674. *An Account of Two Voyages to New England made during the Years 1638, 1663*. Widdows, London, United Kingdom. vii+211 pp.

Kelner-Pillault, S. 1969a. Abeilles fossiles ancestres des apides sociaux. *Proceedings of the VI Congress of the IUSSI [International Union for the Study of Social Insects], Bern* 1969:85–93.

Kelner-Pillault, S. 1969b. Les abeilles fossiles. *Memoire della Società Entomologica Italiana* 48:519–534.

Kontrimavichus, V.L. 1985. *Berinigia in the Cenzoic Era: All-Union Symposium "The Bering Land Bridge and its Role in the History of Holarctic Floras and Faunas in the Late Cenozoic"*. A.A. Balkema, Rotterdam, The Netherlands, xv + 724 pp.

Kotthoff, U. 2005. Über einige Hymenoptera (Insecta) aus dem Unter-Miozän des Randecker Maars (Schwäbische Alb, Südwestdeutschland). *Stuttgarter Beiträge zur Naturkunde, Serie B, Geologie und Paläontologie* 355:1–25.

Kürschner, W.M., Z. Kvaček, and D.L. Dilcher. 2008. The impact of Miocene atmospheric carbon dioxide fluctuations on climate and the evolution of terrestrial ecosystems. *Proceedings of the National Academy of Sciences, USA* 105(2):449–453.

Lutz, H. 1993. *Eckfeldapis electrapoides* nov. gen. n. sp., eine "Honigbiene" aus dem Mittel-Eozän des "Eckfelder Maares" bei Manderscheid/Eifel, Deutschland (Hymenoptera: Apidae, Apinae). *Mainzer naturwissenschaftliches Archiv* 31:177–199.

Maa, T.C. 1953. An inquiry into the systematics of the tribus Apidini or honeybees (Hym). *Treubia* 21:525–640.

Mardulyn, P., and S.A. Cameron. 1999. The major opsin in bees (Insecta: Hymenoptera): A promising nuclear gene for higher level phylogenetics. *Molecular Phylogenetics and Evolution* 12(2):168–176.

Michener, C.D. 1990. Classification of the Apidae (Hymenoptera). *University of Kansas Science Bulletin* 54(4):75–164.

Michener, C.D. 1997. Genus-group names of bees and supplemental family-group names. *Scientific Papers, Natural History Museum, University of Kansas* 1:1–81.

Michener, C.D. 1999. The corbiculae of bees. *Apidologie* 30(1):67–74.

Michener, C.D. 2000. *The Bees of the World*. Johns Hopkins University Press, Baltimore, Maryland, USA. xiv + [i] + 913 pp.

Michener, C.D. 2007. *The Bees of the World* [2nd Edition]. Johns Hopkins University Press, Baltimore, Maryland, USA. xvi + [i] + 953 pp.

Nel, A., X. Martínez-Delclòs, A. Arillo, and E. Peñalver. 1999. A review of the Eurasian fossil species of the bee *Apis*. *Palaeontology* 42(2):243–285.

Noll, F.B. 2002. Behavioral phylogeny of corbiculate Apidae (Hymenoptera; Apinae), with special reference to social behavior. *Cladistics* 18(2):137–153.

Petrov, P. 1992. Distribution and phylogenesis of the bee genus *Apis* (Hymenoptera, Apidae). *Uspechi Sovremennoi Biologii, Moscow* 112:359–372. [In Russian]

Prentice, M. 1991. Morphological analysis of the tribes of Apidae. Pages 51–69 *in* D.R. Smith, ed., *Diversity in the Genus* Apis. Westview Press, Boulder, Colorado.

Prokop, J., and A. Nel. 2003. New fossil Aculeata from the Oligocene of the České Středohoří Mts. and the Lower Miocene of the Most Basin in northern Czech Republic (Hymenoptera: Apidae, Vespidae). *Acta Musei Nationalis Pragae, Series B, Natural History* 59(3–4):163–171.

Radloff, S.E., C. Hepburn, H.R. Hepburn, S. Fuchs, S. Hadisoesilo, K. Tan, M.S. Engel, and V. Kuznetsov. In review. Population structure and classification of *Apis cerana* Fabricius, 1793. *Apidologie*.

Rasnitsyn, A.P. 2006. Ontology of evolution and methodology of taxonomy. *Paleontological Journal* 40(supplement 6):S679–S737.

Rebêlo, J.M.M. 2001. *Historia Natural das Euglossíneas: as Abelhas das Orquídeas*. Lithograf Editora, São Luis, Brazil. 152 pp.

Retallack, G.J. 2004. Late Miocene climate and life on land in Oregon within a context of Neogene global change. *Palaeogeography, Palaeoclimatology, Palaeoecology* 214(1–2):97–123.

Roig-Alsina, A., and C.D. Michener. 1993. Studies of the phylogeny and classification of long-tongued bees (Hymenoptera: Apoidea). *University of Kansas Science Bulletin* 55(4):123–162.

Roussy, L. 1937. Contributions a l'étude de l'abeille tertiaire, de ses parasites et de ses ennemis. *La Gazette Apicole, Montfavet* 388:49–72.

Ruttner, F. 1988. *Biogeography and Taxonomy of Honeybees*. Springer Verlag, Berlin, Germany. xxii + 284 pp.

Ruttner, F. 1992. *Naturgeschichte der Honigbienen*. Ehrenwirth, Munich, Germany. 357 + [1] pp.

Ruttner, F., E.C. Wilson, R. Snelling, G. Vorwohl, and D. Kauhausen. 1986. Die Evolution des Flügelgeäders der Honigbienen. *Apidologie* 17(4):348–350.

Schultz, T.R., M.S. Engel, and M. Prentice. 1999. Resolving conflict between morphological and molecular evidence for the origin of eusociality in the "corbiculate" bees (Hymenoptera: Apidae): A hypothesis-testing approach. *University of Kansas Natural History Museum Special Publication* 24:125–138.

Schultz, T.R., M.S. Engel, and J.S. Ascher. 2001. Evidence for the origin of eusociality in the corbiculate bees (Hymenoptera: Apidae). *Journal of the Kansas Entomological Society* 74(1):10–16.

Schweigert, G., and G. Bechly. 2001. Bibliographie zur Geologie und Paläontologie des Randecker Maars (Unter-Miozän, Südwestdeutschland) 1825–2000. *Stuttgarter Beiträge zur Naturkunde, Serie B, Geologie und Paläontologie* 302:1–12.

Skorikov, A.S. 1929a. Beiträge zur Kenntnis der kaukasischen Honigbienenrassen, I–V. *Reports on Applied Entomology, Leningrad* 4:1–60. [In Russian, with German summary]

Skorikov, A.S. 1929b. Eine neue Basis für eine Revision der Gattung *Apis* L. *Reports on Applied Entomology, Leningrad* 4:249–270. [In Russian, with German summary]

Smith, F. 1865. On the species and varieties of the honey-bees belonging to the genus *Apis*. *Annals and Magazine of Natural History, series 3* 15:372–380.

Statz, G. 1934. Neue Beobachtungen über fossile Bienen aus dem Tertiär von Rott am Siebengebirge. *Archiv für Bienenkunde* 15(1):1–10.

Statz, G. 1941. Bienen, Blätter und Blüten aus dem rheinischen Braunkohlenwalde. *Nachrichtenblatt für Rheinische Heimatpflege* 13:100–112.

Statz, G. 1944. Honigbienen aus deutschen Braunkohlenwäldern. *Die Umschau* 48(4):63–65.

Stauffer, P.H. 1979. A fossilized honeybee comb from Late Cenozoic cave deposits at Batu Caves, Malay Peninsula. *Journal of Paleontology* 53(6):1416–1421.

Tan, K., S. Fuchs, and M.S. Engel. 2008. An adventitious distal abscissa in the forewing of honey bees (Hymenoptera: Apidae). *Apidologie* 39(6):674–682.

Zeuner, F.E. 1931. Die Insektenfauna des Böttinger Marmors. *Fortschritte der Geologie und Palaeontologie* 9:247–406.

Zeuner, F.E., and F.J. Manning. 1976. A monograph on fossil bees (Hymenoptera: Apoidea). *Bulletin of the British Museum (Natural History), Geology Series* 27(3):149–268.

Zhang, J.-F. 1990. New fossil species of Apoidea (Insecta: Hymenoptera). *Acta Zootaxonomica Sinica* 15(1):83–91. [In Chinese, with English summary]

Copyright © 2009 by the California Academy of Sciences
San Francisco, California, U.S.A.

PROCEEDINGS OF THE CALIFORNIA ACADEMY OF SCIENCES

Series 4, Volume 60, No. 4, pp. 39–51, 7 figs., 1 table May 7, 2009

Two New Species of *Coelorinchus* (Teleostei, Gadiformes, Macrouridae) from the Tasman Sea

Peter McMillan[1] and Tomio Iwamoto[2]
[1]*Museum of New Zealand, Te Papa Tongarewa, P.O. 467, Wellington New Zealand;*
[2]*Department of Ichthyology, California Academy of Sciences, 55 Music Concourse Drive, San Francisco, CA 94118 U.S.A.; Email: tiwamoto@calacademy.org*

Two new deepwater *Coelorinchus* species were captured during a joint Australia/New Zealand marine fauna survey of the West Norfolk and South Norfolk Ridges and south Lord Howe Rise in May-June 2003. *Coelorinchus osipullus* sp. nov. is similar to the Australasian *C. celaenostomus* McMillan and Paulin and had been mistakenly identified as such in collections made by French surveys off New Caledonia and the Loyalty Islands, but the new species has pale to dusky lips and mouth compared to the intense black markings of *C. celaenostomus*. It is also very similar to *C. sheni* Chiou, Shao, and Iwamoto from Taiwan, but has a shorter and narrower snout and blackish gums compared to the pale gums of *C. sheni*. *Coelorinchus obscuratus* sp. nov. is most similar to *C. occa* (Goode and Bean) from the western North Atlantic, but the latter has a larger orbit, lacks a blackish orbital rim, and has much more coarsely spinulated scales.

The ridges and seamounts in and around the Tasman Sea between New Zealand and the islands of New Caledonia and the Loyalty Islands have been little explored by vessels sampling the bottom with their collecting gear. The demersal fishes from the area are poorly represented in museum collections, and consequently the fauna is not well known. French research vessels conducted several biodiversity surveys in the Exclusive Economic Zones (EEZ) of New Caledonia, Vanuatu, and the Loyalties from 1984 to the late 1990s (see Richer de Forges 1990 and 1993 for more information on these cruises). The Norfolk Ridge south of New Caledonia was surveyed during the 1991 BERYX 2 cruise and the 1996 HALIPRO 2 cruise, which also surveyed the Loyalty Ridge. During both these cruises, specimens of *Coelorinchus osipullus* sp. nov. were collected but were misidentified as *C. celaenostomus* McMillan and Paulin, 1993 in publications by Iwamoto and Merrett (1997) and Merrett and Iwamoto (2000). From 11 May to 5 June 2003, the south ends of the Norfolk Ridge and Lord Howe Rise and the West Norfolk ridge were sampled during a biodiversity survey (NORFANZ) funded by New Zealand and Australia (Clark and Roberts 2008). During this cruise a variety of trawls and nets was deployed from the National Institute of Water and Atmospheric Research (NIWA) vessel *Tangaroa*. The fishes were mostly caught using a high-opening bottom trawl that lacked wings, or a full-wing trawl, although some were taken using an epibenthic sled and a beam trawl. Continental, insular, and seamount slope depths down to about 1789 m were sampled.

This report describes two new grenadiers (family Macrouridae) of the genus *Coelorinchus*. The genus is well represented in the Australasian region with about 21 species known from New Zealand (unpublished data), about 35 from Australia (Iwamoto and Williams 1999; Iwamoto and Graham 2001, 2008), and 17 from the New Caledonian region (Merrett and Iwamoto 2000). Several species are confined to either New Zealand or Australia and some have restricted distributions around those countries, so it is not surprising to encounter apparently new species during a survey of a previously poorly sampled region. It is planned to deal with the other macrourids and the family Bathygadidae from the NORFANZ cruise in separate publications.

MATERIALS AND METHODS

Our study specimens are deposited in AMS, BMNH, CAS, CSIRO, MNHN, NMNZ, and NMV. The reader is referred to Eschmeyer's (1998) *Catalog of Fishes* for institutional abbreviations and for detailed references and authorities to taxonomic names used. Methods for taking counts and making measurements follow procedures of Gilbert and Hubbs (1916), slightly modified by Iwamoto (1970) and Iwamoto and Sazonov (1988).

Genus *Coelorinchus* Giorna, 1809

[N.B. See Iwamoto (1990) for diagnosis of genus and key to species of the world. The reason for the spelling change back to the use of the dipthong *oe* is discussed by Iwamoto (2008: xi)]

Coelorinchus osipullus sp. nov.

Figures 1–3.

Caelorinchus celaenostomus (non McMillan and Paulin 1993): Iwamoto and Merrett 1997: 490–493, fig. 7 (4 specimens, 224–520 mm TL; Norfolk Ridge; 600–1340 m). Merrett and Iwamoto 2000: 743–744 (9 specimens [including three reported by Iwamoto and Merrett 1997], 310–710 mm TL, Norfolk and Loyalty ridges; 643–1340 m).

Caelorinchus sp. 1: Clark and Roberts 2008:51, App. 4, color plate.

DIAGNOSIS.— A species of *Coelorinchus* lacking external evidence of a light organ, anus immediately before origin of anal fin; snout long, about 2.5 into head length, anterolateral margins not completely supported by bone. Premaxillary teeth in a long band, the outer series only slightly enlarged. Underside of head fully scaled with small scales armed with discrete uniform rows of small spinules. Mouth with black gums. Prominent body markings, with 10 or 11 wide dark bars or saddles, most of which do not extend much below lateral midline; bands interrupted by narrow white (or pale) spaces oriented vertically or at slightly oblique angles; anal fin with broad dark distal margins, the anterior portion of fin with distal tips white.

TYPE SPECIMENS.— (11 specimens, all except MNHN 1996-363 collected by the R/V Tangaroa).— Holotype: MNHN 1998-237 (172 mm HL, 555+ mm TL); Loyalty Ridge, 23°31.15'S, 169°36.64'E, 685–831 m; HALIPRO 2, stn. BT 3; 6 Nov. 1996. Paratypes: **Norfolk Ridge**: MNHN 1996-363 (ex. NMNZ P.27431) (57.9 HL, 224 TL); 24°53.0'S, 168°22.3'E, 600–650 m; BERYX 2, stn. 2, R/V Alis; 24 Oct. 1991. CAS 90982 (143 HL, 520 TL) and MNHN 1998-322 (not measured); 25°19.93'S, 168°56.56'E, 697–1340 m; HALIPRO 2, stn. BT 32; 12 Nov. 1996. NMNZ P.40991 (ex. CAS 90670)(116 HL, 320 TL) and BMNH 1997.5.21:35 (149 HL, 515+ TL); 25°23.03'S, 168°56.47'E, 643–1233 m; HALIPRO 2, stn. BT 34; 12 Nov. 1996. MNHN 1998-235 (175 HL, 627 TL), CAS 90984 (116 HL, 310 TL), and BMNH 1997.5.21:39 (127 HL, 410+ TL); 25°23.00'S, 168°56.99'E, 640–740 m; HALIPRO 2, stn. BT 35; 12 Nov. 1996. BMNH 1997.5.21:63 (188 HL, 710 TL); 23°13.86'S, 167°57.19'E, 650–660 m; HALIPRO 2, stn. BT 91; 23 Nov. 1996. CSIRO H6005-04 (177 HL, 646 TL); 29°53.11'S, 167°49.04'E, 650–666 m; TAN0308, NORFANZ stn. 17; 14 May 2003.

COUNTS AND MEASUREMENTS (holotype in boldface, followed by range in paratypes).— 1D. **II,9**, II,8–9; P. **i16**, i17–i19; V. **7**, 7; inner GR-I **2+7**, (2–3) + 6, GR-II (outer/inner) **0+8**, 0+6 / **2+7**, (1–2) + 7; scales below 1D. **6.5**, 6–6.5, below mid-base 1D. **4.5**, 4.5–6; below 2D. **5.5**, 5.5–6.5; over distance equal to predorsal length **36**, 36–43; pyloric caeca 41–56 (2 paratypes).

Total length **555+ (large pseudocaudal)**, 224–710 mm; HL **172**, 58–188 mm; preanal length

250, 77–264 mm. The following in percent of HL: snout length **42**, 39–41; preoral length **31**, 23–31; internasal width **19**, 16–20; interorbital width **25**, 21–24; orbit diam. **20**, 21–25; suborbital width **15**, 13–15; postorbital length **39**, 35–39; distance orbit to preopercle angle **43**, 38–44; upper jaw length **31**, 27–33; length barbel **6**, 8–13; length outer gill slit **17**, 16–17; body depth **58**, 53–62; interspace between 1D. and 2D. **20**, 18–22; height 1D. **44**, 45–50; length base 1D. **19**, 16–19; length P. **45**, 39–46; length outer V ray **28**, 30–45.

Description.— Body relatively shallow, greatest depth under origin of first dorsal fin about 1.6–1.9 into HL. Head large, length about 2.6–3.9 times into total length; broadly cone-shaped, greatest width about equal to greatest depth above angle of lower jaw; least width across interorbital space less than or about equal to orbit diameter, greater than least width across internasal ridges. Snout moderately long, about equal to postorbital length, slender, pointed in lateral and dorsal views, sides viewed from above converge in gentle uniform curves to a narrowly rounded tip that lacks a sharp, stout, well-defined terminal scute. Narrow, sharply defined clefts running on both sides of median series of scales. Ventral profile of snout similarly gently curved, its ventral (preoral) length much shorter than snout length. Anterolateral margins of snout incompletely supported by bone or heavy scute-like scales. Mouth large, jaws relatively unrestricted by lip folds, anterior edge of lips slightly forward of vertical through anterior edge of nasal fossa; posterior margin of maxilla more or less below posterior one-third to one-fourth of orbit. Lips thick and papillaceous. Chin barbel slender, well developed, its length 0.3–0.6 of orbit. Greatest orbit diameter about 1.6–2.1 into snout length, 4.0–5.1 into HL, about 1.5–2.1 times into distance orbit to angle of preopercle. Exposed portions of combined opercle and subopercle bones narrow and deep, posteroventral tip of subopercle terminates in a narrow tip. Preopercle large, broad, with posteroventral end extended into a long, relatively narrow lobe. Suborbital region relatively flat, with suborbital ridge low but forming a broad shelf, the depth of which exceeds half that of the suborbital width. Angle formed (in cross-section) by suborbital sharp but very obtuse.

Teeth in both jaws all small, conical, in a relatively broad tapered band in upper jaw, with an outer series of very slightly larger teeth; band in lower jaw 1–4 teeth wide, tapering to a single row posteriorly, and extending more than three-fourths length of rictus.

Origins of pectoral and pelvic fins about on same vertical, origin of first dorsal fin slightly behind that vertical. Fins except most rays of second dorsal fin well developed. First dorsal fin lacking any prolonged rays; its height greater than snout length and about equal to distance orbit to preopercle; its base about equal to or shorter than interspace between first and second dorsal fins. Pectoral fin length slightly less than height of first dorsal, its tip extending posteriorly to vertical through origin of anal fin. Pelvic fin with outer ray slightly prolonged into a hair-fine tip that barely extends to, or falls short of, anal fin origin. Anal fin well developed, long based, extending to end of tail where it is confluent with second dorsal fin. Second dorsal fin low over almost entire length, its longest anterior rays scarcely longer than vertical diameter of posterior nostril.

Scales large, adherent, covered with discrete divergent rows of short, narrow, overlapping spinules that form sharp serrated crest-like ridges; none of the spinule rows enlarged. Scales below interspace of first and second dorsal fins with 5–7 divergent rows of spinules. Head scales highly variable in size and nature of spinulation; many on operculum (to suborbital ridge) large with widely divergent spinule rows. Scales of suborbital ridge stout, coarsely modified, in two rows, well defined from anterolateral angle of snout posteriorly to near end of preopercle; scales above large modified scales in about 3 rows. Nasal fossa almost fully covered with small scales having 1–3 spinule rows. Underside of snout and lower jaw rami fully scaled; each small scale with 1–3 short rows of low spinules.

No external sign of light organ.

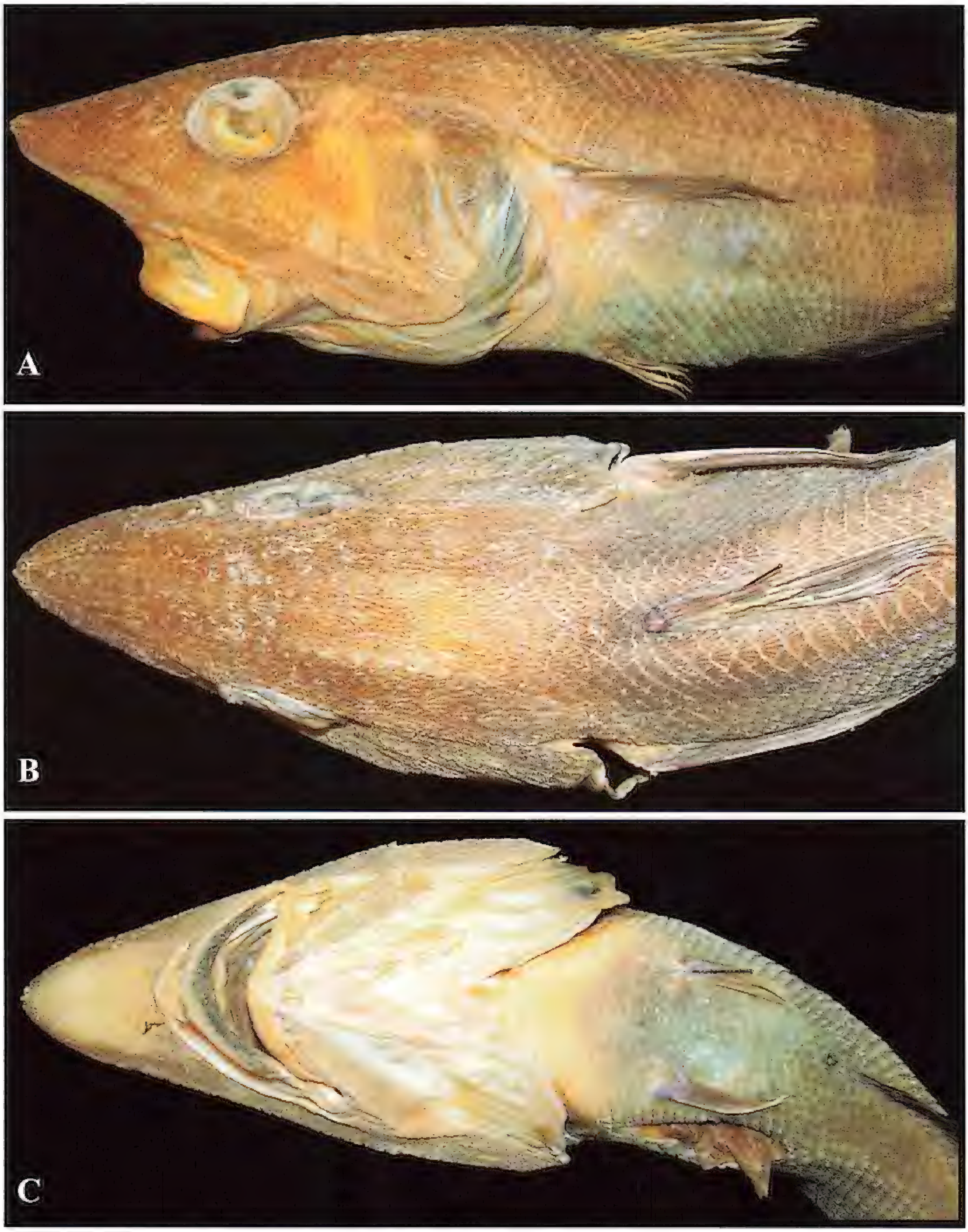


FIGURE 1. *Coelorinchus osipullus* sp. nov. Holotype, MNHN 1998-237 (172 mm HL, 555+ mm TL); Loyalty Ridge, 23°31.15'S, 169°36.64'E, 685-831 m; HALIPRO-II stn. BT 03; 6 Nov. 1996. (A) Lateral view; (B) dorsal view of head; (C) ventral view of head and trunk.

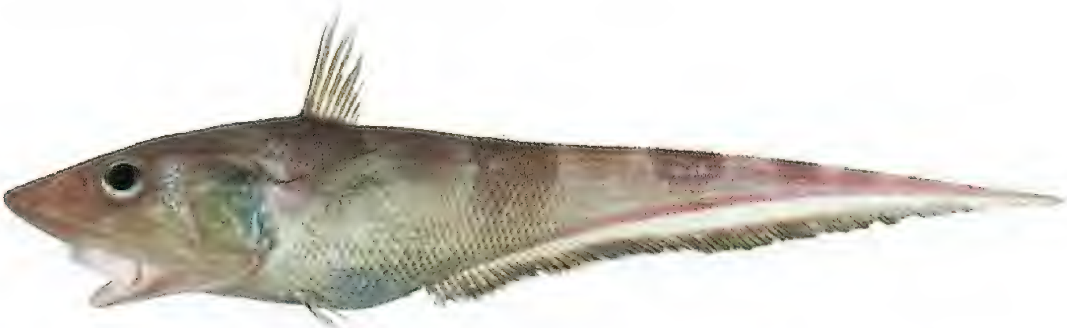


FIGURE 2. *Coelorinchus osipullus* sp. nov. Paratype, CSIRO H6005-04 (177 mm HL, 646 mm TL); Norfolk Ridge, 29°53.11'S, 167°49.04'E, 650–666 m; TAN0308, NORFANZ stn. 17; 14 May 2003. Photograph ©NORFANZ Founding Parties, photographers Robin McPhee (Te Papa) & Mark McGrouther (AMS).

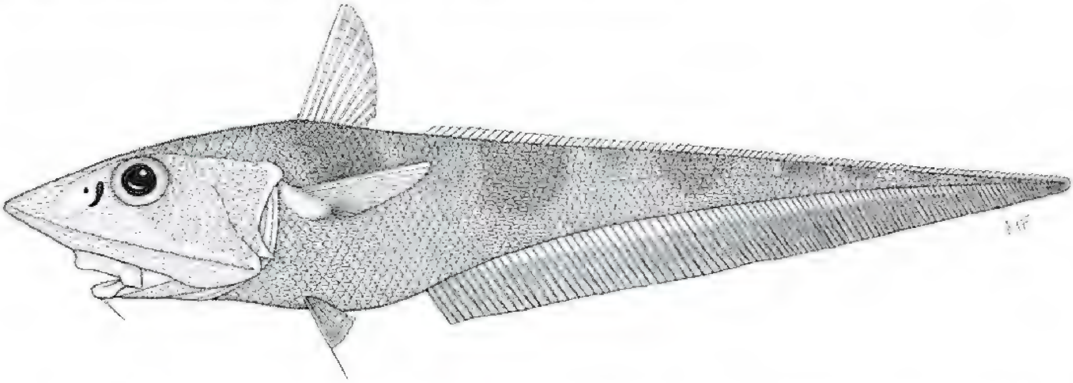


FIGURE 3. *Coelorinchus osipullus* sp. nov. Paratype, CSIRO H6005-04 (177 mm HL, 646 mm TL); West Norfolk Ridge, 29°53.11'S, 167°49.04'E, 650–666 m; TAN0308, NORFANZ stn. 17; 14 May 2003. Drawn by Michelle Freeborn (Te Papa).

Fresh color of body overall dark brownish dorsally and straw ventrally, bluish over abdomen and about ⅓ to ½ of chest; 9–11 distinct bars or saddles, interspersed in some specimens with sharply defined, narrow, pale, vertical to diagonal markings, although in others, body paler with pale spaces between dark saddles much broader. First saddle broad, deep, beginning on nape and spanning entire length of 1D and extending ventrally below lateral midline and pectoral fin; second through fourth saddle extending ventrally to about lateral midline. Odd-numbered saddles (first, third, fifth, etc.) usually much darker than others. Ventral half of body below lateral midline paler; small areas ventrally on abdomen (but not on chest anterior to pelvic bases and shoulder girdle) purplish. Dorsal surfaces of head and snout dark brown; underside including lips, gular and branchiostegal membranes pale to whitish but with dark pigmentation of gill cavity showing through membranes between uppermost branchiostegal rays. Mouth lining pale to blackish, except pale peripherally and at angles of jaws; gill and abdominal cavities black; gums dusky to black; lips pale. A faint, narrow, dark orbital ring. First dorsal fin blackish, long spinous ray with distal portion white; rays of second dorsal fin pale except over saddles, where they are black. Anal fin pale along base but with broad black distal margin over entire length of fin; anterior rays with additional white tips distal to black portions. Pectoral fins black except for uppermost and several lowermost rays pale or clear. Pelvic fins blackish except for outermost prolonged ray, which is whitish distally. Preserved specimens have less distinct but still obvious saddles on the body, anal fin with broad black distal margin over entire length of fin, and gums of mouth dusky to black.

DISTRIBUTION.— Known only from seamounts of the Loyalty and Norfolk ridges between New Caledonia and New Zealand (Fig. 4). Capture depths ranged from 600 to 1340 m.

SIZE.— Attains a maximum size of more than 188 mm HL and 710 mm TL.

ETYMOLOGY.— The specific name is taken from the Latin *os* meaning mouth, and the Latin *pullus* meaning dusky or dark colored, and refers to the dark gums of this species.

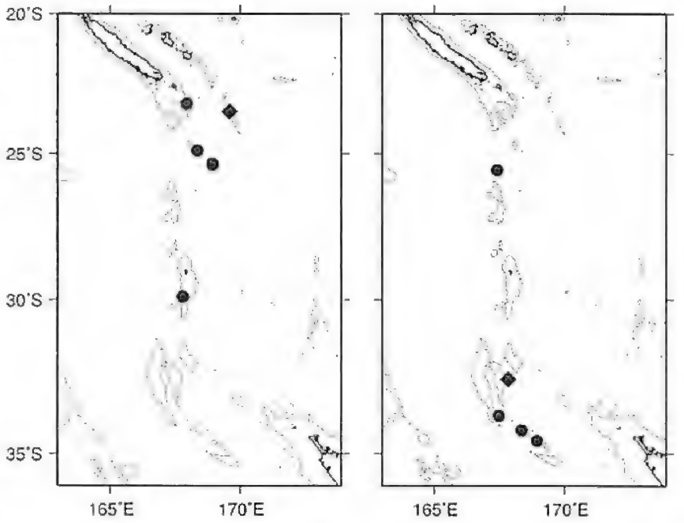


FIGURE 4 Collection localities of *Coelorinchus osipullus* sp. nov. (left) and *C. obscuratus* sp. nov. (right) in the Tasman Sea. Holotype locality is shown as a diamond.

COMPARISONS.— *Coelorinchus osipullus* is most similar to *C. sheni* Chiou, Shao, and Iwamoto 2004, described from three specimens taken off Taiwan. The snout in *C. sheni* is broader and longer, reflected in the snout length, which is 41–56% of HL, compared with 39–42% in the new species. (See Table 1 for additional comparisons of proportions and counts.) The internasal and interorbital widths as a percentage of the snout length are greater in *C. sheni*, 51% and 61% of snout length, respectively, compared with 41–51% and 54–61% in *C. osipullus*. The ridges of the head are also significantly thicker and more spiny in *C. sheni*. The width across the outer edges of the occipital ridges is 39% of the snout length in a male paratype of *C. sheni* (CAS 215541), but only 30–33% in the new species. The posteroventral tip of the subopercle in *C. sheni* is not developed into a slender tag as it is in *C. osipullus*. The premaxillary teeth in *C. sheni* have an outer series of relatively large canine teeth, significantly larger than those in the new species. Pigmentation differences also exist: prominent black distal margin of anal fin in *C. osipullus*, compared with entirely black fin in *C. sheni*; and blackish gums in *C. osipullus*, compared with pale gums in *C. sheni*.

Iwamoto and Merrett (1997) and Merrett and Iwamoto (2000) confused the new species with *C. celaenostomus* McMillan and Paulin, 1993 (Fig. 5). The two species are readily distinguished, however, by several prominent features, including: (1) lips and mouth of *C. celaenostomus* intensely black (cf. pale to dusky in *C. osipullus*); (2) broad bluish band completely encircling trunk in *C. celaenostomus* (cf. pale bluish only over abdomen); (3) only five distinct saddles on body, those posteriorly indistinct if present (cf. 9–11 prominent saddles); (4) black margin of anal fin terminating well before end of tail (cf. extends to end of tail); (5) orbit diameter more than two times into snout length (cf. less than two times); (6) a small, narrow black dermal window of light organ anterior to anus (cf. no dermal window); (7) upper jaw teeth uniform, lacking enlarged outer series (cf. outer series slightly enlarged); and (8) and body scales below anterior end of second dorsal fin with five, at the most, widely spaced spinule rows (cf. closely spaced with six or seven rows). Other proportional and meristic characters also separate the two species (see Table 1).

The overall body and head shape, characteristics of the scales, absence of bony support for the anterolateral margin of the snout, small or inconspicuous light organ immediately anterior to anus,

TABLE 1. Counts and measurements of three *Coelorinchus* species. Data for *C. sheni* and *C. celaenostomus* mostly from original descriptions. Figures in square brackets for *C. sheni* from CAS 215541 (paratype).

	C. osipullus N = 10	*C. sheni* N = 3	*C. celaenostomus* N = 48
Total Length (mm)	224–710	420–937+	260–828+
Head Length (mm)	58–188	113–257	76–273
Measurements in %HL			
Snout Length	39–42	41–56	45–52
Preoral Length	23–31	[31]32–36	36–45
Internasal Width	16–20	20–21[23]	12–19
Interorbital Width	21–25	25–26	19–22
Orbit Diameter	20–25	20–21	17–23
Suborbital Width	13–15	[14]	9–12
Postorbital Length	35–39	37–40	27–34
Orbit to Preopercle	38–44	[40]	29–41
Upper Jaw	27–33	[29]30–37	26–33
Length Barbel	6–13	9–11	5–11
Length 1st Gill Slit	16–19	10–13[17]	
Body Depth	53–62	[56]	36–51
1D-2D Interspace	18–22	[15]22–23	13–23
Height 1D	44–50	45–48[49]	32–40
Length P	39–46	44–50	33–40
Length V	28–45	42	21–37
Interoccipital Space	12–13	[16]	
Counts			
1D (segmented rays)	8–9	8–9	7–8
P (excl. i)	16–19	18–19	13–17
GR-I (mesial)	8–9	9–10	8–11
GR-II (lateral)	6–8	6–8[9]	8–10
Scales 2D	5.5–6.5	4.5–5.0	6–8
Scales 1D	4.5–5.5	5–6	6–9
" lat. line	36–43	33–41	47–51
Pyloric caeca	41–56 (2 spec.)		37–53 (mean = 44.6)

large unrestricted mouth with long bands of teeth in both jaws, and prominent saddle markings on the body relate these two species with *C. quadricristatus* (Alcock, 1891), *C. tokiensis* (Steindachner and Döderlein, 1887), *C. hexafasciatus* Okamura, 1982, and *C. longicephalus* Okamura, 1982. The last three species are readily distinguished from *C. osipullus* by their naked underside of head (except below the posterior end of the preopercle angle), small external dermal window of the light organ, and fully black anal fin. *Coelorinchus quadricristatus* shares most diagnostic features with the new species, but it lacks the prominent anal-fin markings, and it has a shorter first dorsal fin height (about 30–35% of HL, cf. 46–50%).

REMARKS.— The new species is part of a complex of at least seven species (*C. celaenostomus, C. hexafasciatus, C. longicephalus, C. quadricristatus, C. sheni, C. tokiensis*) that appears to be associated with islands and seamounts in tropical waters of the Pacific and Indian oceans. *Coelor-*

inchus tokiensis has been captured off southern Japan and the East China Sea, *C. hexafasciatus* and *C. longicephalus* off the Kyushu-Palau Ridge south of Japan, *C. sheni* off Taiwan, *C. quadricristatus* off the Andaman Islands in the Indian Ocean, *C. celaenostomus* off New Zealand's North Island, the Challenger Plateau, and the southern part of the Norfolk Ridge, and the new species on the northern part of the Norfolk and Loyalty ridges. Some aspects of the physiognomy of these fishes show peculiarities quite unlike those found in other members of the genus. Comparison of gene sequences and the internal morphology of this species complex should reveal its relationship with other clades within the large and diverse genus *Coelorinchus*. Species of this complex are among the largest members of the family Macrouridae (sensu stricto, excluding trachyrincids): *C. sheni* (>90 cm), *C. longicephalus* (>89 cm), and *C. celaenostomus* (>83 cm). They attain sizes that are exceeded by only a few members of the genera *Coryphaenoides* and *Macrourus*, and the North Pacific giant *Albatrossia pectoralis* (210 cm: Tuponogov et al. 2008:291).

Coelorinchus obscuratus **McMillan and Iwamoto, sp. nov.**

Figures 6–7.

Caelorinchus sp. NFZ3: Clark and Roberts 2008: 51, App. 4 (listed).

DIAGNOSIS.— A species of *Coelorinchus* with an almost scaleless ventral surface of the head. Nasal fossa with large scaleless area anteriorly extending to nasal ridge and ventrally to or near suborbital ridge. No external evidence of a light organ, anus immediately before origin of anal fin. Snout long, about 2.0–2.3 into head length, with strong terminal scute, which is elongate ventrally, anterolateral margins not completely supported by bone. Body pale grayish-brown, lacking prominent markings; a narrow blackish eye ring; lips, mouth, and gill cavities dusky to black.

TYPE SPECIMENS.— (17 specimens, all collected by the R/V *Tangaroa*). —Holotype: NMNZ P.39373 (109 mm HL, 375 mm TL); West Norfolk Ridge, 32°36.39'S, 167°50.59'E, 1331–1345 m; TAN0308, NORFANZ stn. 121; 30 May 2003. Paratypes: **West Norfolk Ridge**: AMS I.42762–006 (2 spec., 63.2–111 mm HL, 220–381 mm TL) and CAS 218477 (2 spec., 62–75 mm HL, 209+ to 248+ mm TL); same station as holotype. NMNZ P.39553 (2 spec., 124–152 mm HL, 435+ to 450+ mm TL), AMS I.42769–003 (2 spec., 130–139 mm HL, 341+ to 446+ mm TL), CAS 218673 (1 spec., 118 mm HL, 385+ mm TL), and CSIRO H6083–01 (1 spec., 131 mm HL, 422 mm TL); 34°14.33'S, 168°21.18'E, 1195–1202 m; TAN0308, NORFANZ stn. 146; 3 June 2003. NMV A25175–003 (1 spec., 132 mm HL, 389+ mm TL), 34°34.26'S, 168°56.53'E, 1013–1350 m; TAN0308, NORFANZ stn. 156; 4 June 2003. CAS 218451 (4 spec., 26.5–59 mm HL, 90+ to 218 mm TL), 33°46.55'S, 167°29.28'E, 1431–1460 m; TAN0308, NORFANZ stn. 103; 29 May 2003. **Norfolk Ridge**: CAS 90752 (1 spec., 88 mm HL, 293 mm TL), , 25°34'S, 167°25'E, 1132–1160 m; HALIPRO2, stn. BT 42; 15 Nov. 1996.

Counts and measurements (holotype in boldface, followed by range in paratypes).— 1D. **II**, **7**, II,7–9; P. **i15**, i14–i19; V. **7**, 7; GR-I inner **2 + 5**, (0–2) + 5–7 (6–9 total) GR-II inner **1 + 6**, (0–2) + 5–7 (total 6–8) scales below 1D. **5**, 5–6, below mid-base 1D. **5**, 4–5.5; below 2D. **6**, 4.5–6; over distance equal to predorsal length **38**, 33–41; pyloric caeca **9**, 8–11 (10 spec.).

Total length **375**, 90–450 mm; HL **109**, 26.5–152 mm; preanal length **156**, 36–208 mm. The following in percent of HL: snout length **48**, 43–49; preoral length **45**, 39–47; internasal width **17**, 16–24; interorbital width **21**, 20–23; orbit diam. **23**, 21–29; suborbital width **13**, 12–15; postorbital length **29**, 27–31; distance orbit to preopercle angle **31**, 29–34; upper jaw length **20**, 19–29; length barbel **7**, 2–9; length outer gill slit **10**, 5–12; body depth **45**, 29–44; interspace between 1D. and 2D. **15**, 12–19; height 1D. **35**, 30–41; length base 1D. **11**, 10–16; length P. **29**, 28–44; length outer V ray **30**, 26–45.

DESCRIPTION.— Body relatively shallow, greatest depth under origin of first dorsal fin about 2.2–3.4 into HL, body width across pectoral fin bases less than snout length, 2.1–2.5 into HL. Head

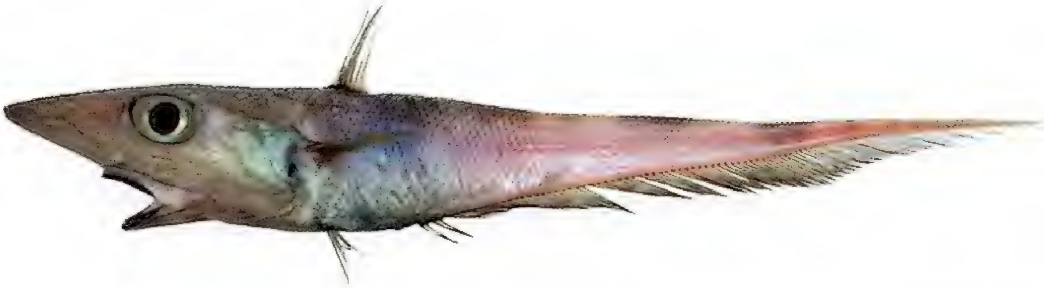


FIGURE 5. *Coelorinchus celaenostomus*. CSIRO H6054-01 (148 mm HL, 490 mm TL); West Norfolk Ridge, 33°49.47'S, 167°03.45'E, 804–944 m; TAN0308, NORFANZ stn. 93; 27 May 2003. Photograph ©NORFANZ Founding Parties, photographers Robin McPhee (Te Papa) & Kerryn Parkinson (AMS).

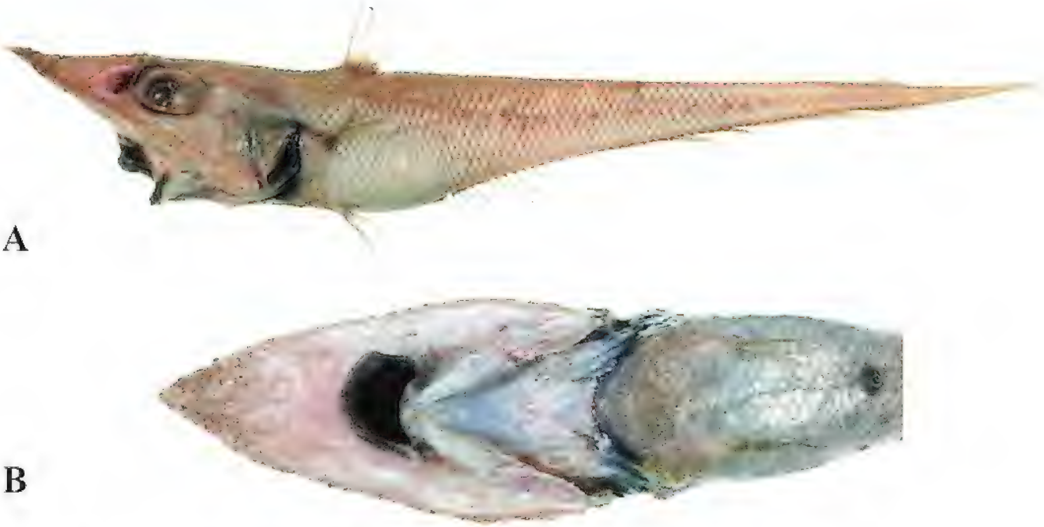


FIGURE 6. *Coelorinchus obscuratus* sp. nov. Holotype, NMNZ P.39373 (109 mm HL, 375 mm TL) West Norfolk Ridge, 32°36.39'S, 167°50.59'E, 1331–1345 m; TAN0308, NORFANZ stn. 121; 30 May 2003. (A) Lateral view; (B) ventral view of head and trunk. Photograph ©NORFANZ Founding Parties, photographers Robin McPhee (Te Papa) & Kerryn Parkinson (AMS).

long, 2.6–3.7 into total length. Snout long, about 1.5 times postorbital length, slender, and converging to a sharply pointed stout, well-defined terminal scute. Underside of head covered with dark long fine papillae, more prominent anterior to mouth. Mouth small, with anterior of lips about level with a vertical through nostrils; posterior end of maxilla below vertical through posterior two thirds of orbit. Lips thin and covered with small papillae in smaller specimens, thicker and more prominently papillated in larger specimens. Chin barbel small, slender, its length about a third of orbit. Greatest orbit diameter 1.6–2.3 into snout length, 3.5–4.7 into HL, 1.1–1.5 into distance orbit to angle of preopercle. Exposed posteroventral tip of subopercle small, finely pointed, extending to near posterior end of suborbital ridge. Suborbital ridge angular and armed with stout strongly spinulated scales, well defined from tip of snout posteriorly to near end of preopercle. Anterolateral margins of snout not completely supported by bone.

Teeth in upper jaw small, needle-like, in a broad uniform band. Teeth in lower jaw small, in a narrow band that extends back past rictus.

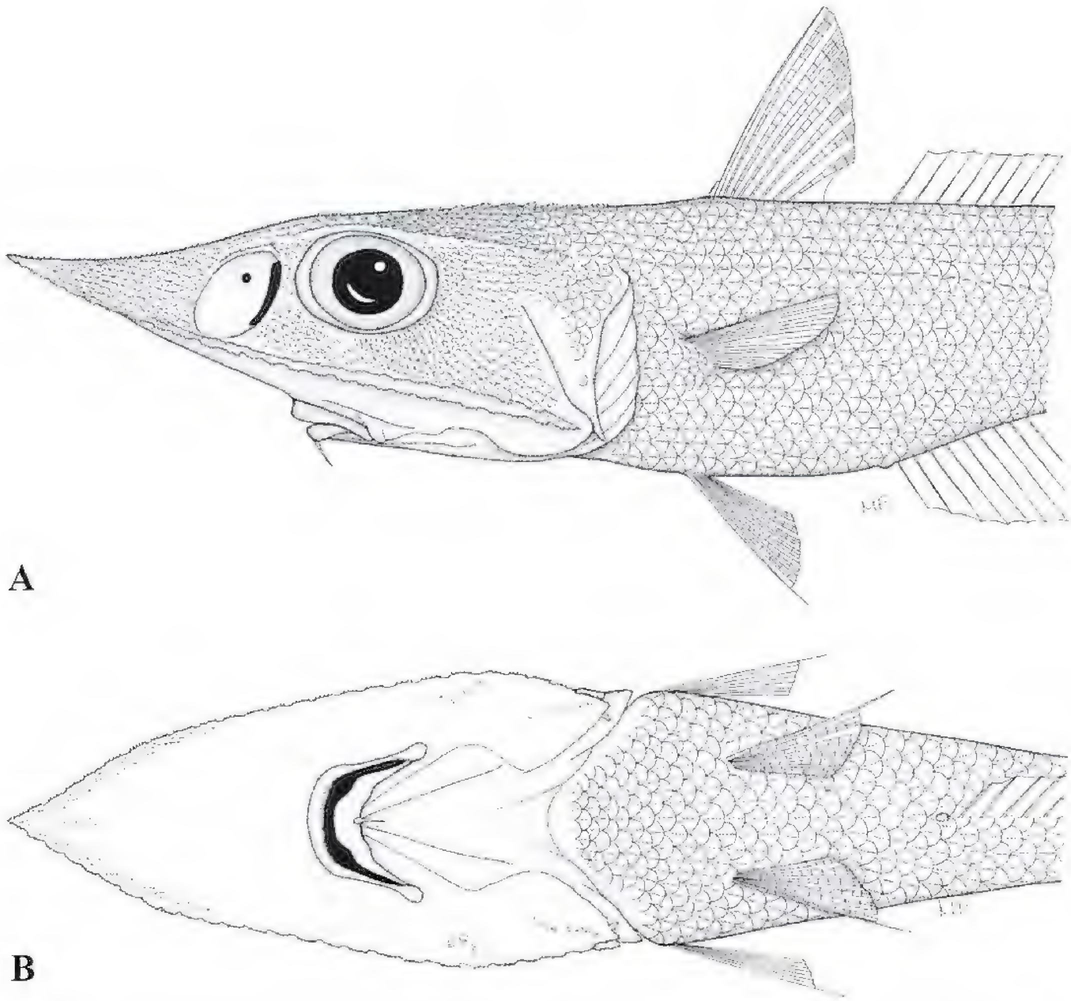


Figure 7. *Coelorinchus obscuratus* sp. nov. Holotype, NMNZ P.39373 (109 mm HL, 375 mm TL) West Norfolk Ridge, 32°36.39'S, 167°50.59'E, 1331–1345 m; TAN0308, NORFANZ stn. 121; 30 May 2003. (A) Lateral view of head and trunk; (B) ventral view of head and trunk. Drawn by Michelle Freeborn (Te Papa).

Origin of pectoral fin slightly ahead of pelvic fins, origin of first dorsal fin about level with a vertical through origin of pelvic fin. Fins except most rays of second dorsal fin well developed. First dorsal fin short, lacking any prolonged rays; its height much less than snout length (1.1–1.5 into snout length) and slightly more than distance orbit to preopercle; its base about equal to interspace between first and second dorsal fins (0.7–1.4 into interspace). Pectoral fin length about equal to height of first dorsal, its tip not extending to origin of anal fin. Pelvic fin with outer ray slightly prolonged into a hair-fine tip that does not extend to anal fin origin. Anal fin well developed, long based, extending to end of tail where it is confluent with second dorsal fin. Second dorsal fin low over almost entire length, its longest anterior rays slightly longer than barbel length.

Scales large, adherent, covered with discrete parallel rows of stout, arrow-head shaped overlapping spinules with the central spinule row enlarged. Scales below interspace of first and second dorsal fins with 6–10 rows of spinules. Nasal fossa almost completely lacking scales anteriorly to the nasal ridge, and ventrally to the suborbital ridge or with a few rows of intervening small scales. Dorsal surface of head almost entirely covered with strong spinulated scales. Smaller specimens with thin naked longitudinal strips on dorsal head. Underside of head and lower jaw lacking scales except for 1–2 longitudinal rows of scales at posterior ends on each side of head, a few scales between posterior angles of lower jaw and suborbital ridge, and a few scute-like scales anteroventrally associated with suborbital ridge.

Fresh body coloration pale grayish-brown, lacking prominent markings. Larger specimens darker. Underside of head pale grayish-brown. Lips dusky to blackish (especially in young), oral cavity dark gray to blackish, and lining of gill cavity and branchiostegal membranes dark bluish-black. Narrow, dark orbital ring more prominent on the anterior, dorsal and ventral rim of orbit. All fins dusky in smaller specimens to blackish in larger specimens and lacking prominent markings. Dark and dusky coloration retained but less obvious in preserved specimens.

DISTRIBUTION.— Only collected from the continental slope of the West Norfolk Ridge west of New Zealand and the Norfolk Ridge south of New Caledonia (Figure 4). Capture depths ranged from 1013–1460 m. This species seems to be one of the deepest-dwelling members of the genus.

SIZE.— Attains a maximum size of more than 152 mm HL and 450 mm TL.

ETYMOLOGY.— The specific name is taken from the Latin meaning darkened or obscured.

COMPARISONS.— *Coelorinchus obscuratus* falls in the Species Group I of Iwamoto (1990) in having no external evidence of a light organ and having no prominent markings on the body. It is similar to *C. labiatus* (Koehler, 1896) from the eastern North Atlantic in having a long snout and an orbit marked with a blackish rim, but *C. labiatus* differs in having an entirely naked underside of head and in having the dorsal surface of head with broad naked areas behind the anterolateral edge of the snout. It also appears similar to *C. occa* (Goode and Bean, 1885) from the central North Atlantic, but that species lacks a blackish rim around the orbit and has much more coarsely spinulated scales. *Coelorinchus aratrum* Gilbert, 1905 is a similar long-snouted species from Hawaii but has fewer (3–5) divergent spinule rows and the first dorsal fin is black at the base, bright white distally. *Coelorinchus doryssus* Gilbert, 1905, also from Hawaii, appears to have a larger mouth and the scales on the dorsal head surfaces are minutely spinous.

REMARKS.— The new species may have a restricted distribution as it was not taken during sampling at depths of 395–2105 m in the New Caledonia region to the north (Iwamoto and Merrett 1997), and it was also not collected during numerous deepwater trawl samples around New Zealand to the south. The species may be difficult to sample because it appears to be deep living, with samples probably being taken closer to the maximum recorded depth and also because it appears to have a very low abundance as it was only taken in small numbers (17 total to date).

ACKNOWLEDGMENTS

We owe Clive Roberts (Te Papa) particular thanks for making possible TI's visit to the NMNZ by providing support from the New Zealand Foundation for Research Science and Technology contract MNZ603 (Clive Roberts, Programme Leader). Research on this project was supported [in part] by the Foundation through Te Papa's Biosystematics of New Zealand EEZ Fishes subcontract within NIWA's Marine Biodiversity and Biosecurity OBI Programme (contract C01X0502). Dr. Roberts also arranged for TI's participation in the NORFANZ cruise; he and the other organizers and participants on that cruise are thanked for their assistance, support, and friendship. Bernard Séret (MNHN) is thanked for enabling TI to participate in the HALIPRO 2 cruise, which was funded by the ZoNéCo Programme of evaluation of the marine resources of the economic zone of New Caledonia. The following curators and staff provided specimens and information for this study:

M. McGrouther (AMS); A. Graham (CSIRO); G. Duhamel, P. Pruvost and R. Causse (MNHN); A. Stewart (Te Papa); D. Bray (NMV). Carl Struthers (Te Papa) cropped and adjusted the photographs. Michelle Freeborn (Te Papa) rendered the excellent drawings of the two species (Figs. 3 and 7); Brent Wood (NIWA, Wellington) produced Figure 4. Dr. Roberts and an anonymous reviewer provided comments on a draft of this paper for which we give our thanks.

LITERATURE CITED

CHIOU, M.–L., K.–T. SHAO, AND T. IWAMOTO. 2004. A new species, *Caelorinchus sheni*, and 19 new records of grenadiers (Pisces: Gadiformes: Macrouridae) from Taiwan. *Zoological Studies* 43(1):35–50.

CLARK, M.R,. AND C.D. ROBERTS. 2008. Fish and invertebrate biodiversity on the Norfolk Ridge and Lord Howe Rise, Tasman Sea (NORFANZ voyage, 2003). *New Zealand Aquatic Environment and Biodiversity Report* No. 28. 131 p.

ESCHMEYER, W.N., ED. 1998. *Catalog of Fishes*. 3 vol. California Academy of Sciences, San Francisco, USA. 2905 pp.

GILBERT, C.H., AND C.L. HUBBS. 1916. Report on the Japanese macrouroid fishes collected by the United States Fisheries steamer "Albatross" in 1906, with a synopsis of the genera. *Proceedings of the United States National Museum* 51:135–214.

IWAMOTO, T. 1970. The R/V *Pillsbury* Deep-Sea Biological Expedition to the Gulf of Guinea, 1964–65. 19. Macrourid fishes of the Gulf of Guinea. *Studies in Tropical Oceanography* 4(2):316–431.

IWAMOTO, T. 1990. Family Macrouridae. Pages 90-317 *in* D. M. Cohen, T. Inada, T. Iwamoto, and N, Scialabba. FAO species catalogue. Vol. 10. Gadiform fishes of the world (Order Gadiformes). An annotated and illustrated catalogue of cods, hakes, grenadiers and other gadiform fishes known to date. *FAO Fisheries Synopsis* No. 125, 10:90–317.

IWAMOTO, T. 2008. A note on the correct spelling of the names *Coelorinchus* (*Caelorinchus*) and *C. coelorhincus* (*caelorhincus*). Page xi *in* A. M. Orlov and T. Iwamoto, eds., *Grenadiers of the World Oceans: Biology, Stock Assessment, and Fisheries*. American Fisheries Society, Symposium 63, Bethesda, Maryland, USA.

IWAMOTO, T., AND K.J. GRAHAM. 2001. Grenadiers (families Bathygadidae and Macrouridae, Gadiformes, Pisces) of New South Wales, Australia. *Proceedings of the California Academy of Sciences*, ser. 4, 52(21):407–509.

IWAMOTO, T, AND K.J. GRAHAM. 2008. Two new Australian grenadiers of the *Coelorinchus fasciatus* species group (Macrouridae: Gadiformes: Teleostei). *Proceedings of the California Academy of Sciences*, ser. 4, 59(5):133-146.

IWAMOTO, T., AND N.R. MERRETT. 1997. Pisces Gadiformes: Taxonomy of grenadiers of the New Caledonia region, southwest Pacific. Pages 473-570 *in* A. Crossnier, editor, Résultats des Campagnes MUSORSTOM, Vol. 18. *Mémoires du Muséum national d'Histoire naturelle* 176:473–570.

IWAMOTO, T., AND YU. I. SAZONOV. 1988. A review of the southeastern Pacific *Coryphaenoides* (sensu lato) (Pisces, Gadiformes, Macrouridae). *Proceedings of the California Academy of Sciences*, ser. 4, 45(3):35-82.

IWAMOTO, T., AND A. WILLIAMS. 1999. Grenadiers (Pisces, Gadiformes) from the continental slope of western and northwestern Australia. *Proceedings of the California Academy of Sciences*, ser. 4, 51(3):105–243.

MCMILLAN, P. J., AND C.D. PAULIN. 1993. Descriptions of nine new species of rattails of the genus *Caelorinchus* (Pisces, Macrouridae) from New Zealand. *Copeia* 1993(3):819–840.

MERRETT, N. R., AND T. IWAMOTO. 2000. Pisces Gadiformes: Grenadier fishes of the New Caledonia region, southwest Pacific Ocean. Taxonomy and distribution, with ecological notes. *In* A. Crossnier, ed., Résultats des Campagnes MUSORSTOM, Vol. 21. *Mémoires du Muséum national d'Histoire naturelle* 184:723–781.

RICHER DE FORGES, B. 1990. Les campagnes d'exploration de la faune bathyale dans la zone économique de la Nouvelle-Calédonie. Explorations for bathyal fauna in the New Caledonian economic zone. Pages 9-54 *in* A. Crosnier, ed., Résultats des Campagnes MUSORSTOM, vol. 6. *Mémoires du Muséum national* *d'Histoire naturelle* (A)145.

Richer de Forges, B. 1993. Campagnes d'exploration de la faune bathyale faites depuis mai 1989 dans la zone économique de la Nouvelle-Calédonie. Liste des stations. Pages 27-32 *in* A. Crosnier, ed., Résultats des Campagnes MUSORSTOM, vol. 10. *Mémoires du Muséum national d'Histoire naturelle* 156.

Tuponogov, V. N., A. M. Orlov, and L. S. Kodolov. 2008. The most abundant grenadiers of the Russian Far East EEZ: distribution and basic biological patterns. Pages 285-316 *in* A. M. Orlov and T. Iwamoto, eds., *Grenadiers of the World Oceans: Biology, Stock Assessment, and Fisheries*. American Fisheries Society, Symposium 63, Bethesda, Maryland, USA.

Copyright © 2009 by the California Academy of Sciences
San Francisco, California, U.S.A.

PROCEEDINGS OF THE CALIFORNIA ACADEMY OF SCIENCES

Series 4, Volume 60, No. 5, pp. 53–68, 8 figs., 2 appendices., 2 tables May 7, 2009

Molecular Phylogeny of Nelsonioideae (Acanthaceae) and Phylogeography of *Elytraria*

Rebecca C. Wenk[1,2] **and Thomas F. Daniel**[1,2]

[1]*Department of Botany, California Academy of Sciences, 55 Music Concourse Drive, Golden Gate Park, San Francisco, CA 94118 U.S.A.; Email: rwenk@calacademy.org;* [2]*Department of Biology, San Francisco State University, 1600 Holloway Avenue, San Francisco, CA 94132 U.S.A.*

Nelsonioideae comprise the basal lineage among clades of Acanthaceae. Species in this subfamily are characterized morphologically by several symplesiomorphies and at least one synapomorphy (descending-cochlear aestivation pattern of the corolla lobes). Phylogenetic relationships were studied among five of the seven genera in the subfamily: *Anisosepalum*, *Elytraria*, *Nelsonia*, *Ophiorrhiziphyllon*, and *Staurogyne*. DNA sequence data from two genic regions (chloroplast *trnS-G* and nrITS) of 22 collections were used to generate phylogenetic trees using parsimony, maximum likelihood, and Bayesian methods of cladistic analysis. Combined molecular analyses all strongly support *Elytraria* as monophyletic, recover a clade consisting of the morphologically similar genera ((*Ophiorrhiziphyllon* + *Staurogyne*) *Anisosepalum*), and are ambiguous with respect to the topologic position of *Nelsonia*. Nelsonioideae include about 170 species that occur primarily in tropical regions of both the Old World and the New World. Phylogeographic analyses of 11 species of the widely distributed *Elytraria* using Fitch optimization and dispersal-vicariance analysis (DIVA) support an African origin for the genus with a single dispersal event to the New World (likely by rafting of seeds or entire plants) followed by radiation and speciation there.

Acanthaceae contain about 220 genera (Scotland & Vollesen 2000) and some 4,000 species (McDade et al. 2008) that occur primarily in tropical and subtropical regions worldwide. Four morphologically distinctive subfamilies were recognized by Lindau (1895): Nelsonioideae, Mendoncioideae, Thunbergioideae, and Acanthoideae. Recent molecular studies have confirmed monophyly for each of these, but suggest that Mendoncioideae and Thunbergioideae might be better treated as sister taxa of a single subfamily, Thunbergioideae (McDade et al. 2008; Borg et al. 2008). Phylogenetic relationships based on a combination of nuclear and chloroplast DNA sequence data have been studied in numerous genera in each of these subfamilies except Nelsonioideae (e.g., Hedrén et al. 1995; Scotland et al. 1995; McDade et al. 2000, 2005, 2008; Manktelow et al. 2001; Kiel et al. 2006; Daniel et al. 2008; Borg et al. 2008). Based on a limited sampling of genera, Nelsonioideae have been shown to be basal to all other lineages of Acanthaceae (e.g., Scotland et al. 1995; McDade et al. 2000, 2008). Studies of phylogenetic relationships and biogeographic patterns based on phylogenetic trees (phylogeography) among genera of this subfamily are particularly desirable to better understand aspects of morphological and molecular evolution in the family and among related lineages of Lamiales.

Nelsonioideae include about 170 species in seven genera that occur primarily in tropical

TABLE 1. Genera, species richness, and geographic distribution of genera of Nelsonioideae. Total number of species per genus is followed in parentheses by number sampled here.

Genera	*No. Species (no. sampled)*	*Geographic Distribution*
Anisosepalum E. Hossain	3 (1)	tropical Africa
Elytraria Michx.	22 (11)	tropical Africa, Madagascar, Indian subcontinent, New World
Gynocraterium Bremek.	1 (0)	northern South America
Nelsonia R. Br.	1—5 (1)	tropical Africa, southern Asia, Australia, New World (native?)
Ophiorrhiziphyllon Kurz	1 (1)	southeastern Asia
Saintpauliopsis Staner	1 (0)	tropical Africa
Staurogyne Wall.	~140 (1)	Africa, Asia, northern Australia, New World

regions of both the Old World (OW) and the New World (NW) (Table 1). The subfamily is characterized by the following morphological traits: lack of cystoliths (symplesiomorphy), lack of retinacula (symplesiomorphy), relatively large numbers of ovules (symplesiomorphy), and descending-cochlear aestivation pattern of the corolla lobes (synapomorphy). Although usually treated within Acanthaceae, this assemblage of genera has also been treated as a tribe of Scrophulariaceae (Bremekamp 1953, 1965) and as a distinct family (Sreemadhavan 1977; Lu 1990).

In this study, we present putative phylogenetic relationships among five of the seven genera of nelsonioids based on sequence data from the internal transcribed spacer region of the nuclear ribosomal repeat (nrITS) and the non-coding chloroplast *trnS-G* intergenic spacer. In addition, sampling within the second largest and most widely distributed genus of the subfamily, *Elytraria*, was more extensive so that phylogenetic and biogeographic relationships of species in this genus might begin to be assessed. Specifically, our goals include: 1) proposing generic relationships within the subfamily, 2) testing monophyly for this sampling of *Elytraria*, 3) proposing specific relationships within *Elytraria*, 4) establishing an area of origin for *Elytraria*, and 5) providing additional biogeographic insights based on phylogeographic analyses.

MATERIALS AND METHODS

TAXON SAMPLING.— Full or partial sequence data of 22 collections, representing five of the seven genera of Nelsonioideae and 11 of the 22 species of *Elytraria*, were obtained (Appendix 1). We were unable to obtain sequence data for samples of *Gynocraterium*, *Saintpauliopsis*, and *E. tuberosa*; samples of the other eight species of *Elytraria* were unavailable. Indeed, many species of *Elytraria* remain poorly collected due to their limited distributions. For example, *E. klugii* is known only by the type collection from Peru. Because one of our goals was to elucidate major biogeographic relationships in *Elytraria*, and because several species are poorly known or collected, our taxon sampling for phylogeographic analyses sometimes included only one representative from a geographic area (e.g., only one of the six species endemic to Cuba was sampled). *Aphelandra maculata* (Acanthoideae) was used as an outgroup; its sequence data were obtained from GenBank. Appendix 1 lists voucher data for each taxon sequenced including: taxon name, GenBank accession number, source, collection data, and type of material (herbarium specimen or fresh sample dried in silica).

MOLECULAR METHODS.— Total genomic DNA was extracted from herbarium samples up to 80 years old or from fresh plant material dried in silica gel by using DNEasy kits (Qiagen Inc., Valencia, CA) following the manufacturer's instructions. The nrITS and *trnS-G* regions were chosen for sequencing because of previous success and significant phylogenetic signal for those loci in other species of Acanthaceae (McDade et al. 2005).

DNA was amplified in 25-µl reactions. The nrITS region was amplified by using a combination of the universal primers its4 (5′-TCC TCC GCT TAT TGA TAT GC-3′) and its5 (5′-GGA AGT AAA AGT CGT AAC AAG G-3′) (White et al. 1990) and the plant-specific primers C26A (5′-GTT TCT TTT CGT CCG CT-3′) and N-nc18S10 (5′-AGG AGA AGT CGT AAC AAG-3′) (Wen & Zimmer 1996). The its4, its5 PCR reaction contained 2.5 µl 10X buffer, 0.438µl 10 mM dNTPs, 0.625 µl 50 mM MgCl2, 0.25 units of Biolase *Taq* polymerase (Bioline, Randolph, MA), and 0.54 µl of each primer (25mM). The PCR program consisted of a denaturing step for 6 minutes at 94°C, 35 amplification cycles of 60s at 94°C, 60s at 50–56°C, 80s at 72°C, and a final extension step of 6 minutes at 72°C in a Biorad MyCycler thermal cycler (Biorad, Hercules, CA). The C26A, N-nc18S10 PCR reaction contained 2.5–3.0 µl 10X buffer, 0.438–1.0 µl 10 mM dNTPs, 0.625–0.75 µl 50 mM MgCl2, 0.25 units of Biolase *Taq* polymerase, and 0.54 µl of each primer (25mM). The PCR program consisted of a denaturing step for 10 minutes at 94°C, 35 amplification cycles of 60s at 94°C, 60–80s at 50°C, 80s at 72°C, and a final extension step of 10 minutes at 72°C in a Biorad MyCycler thermal cycler. The *trnS-G* spacer was amplified by using primers trnS-GCU (5′-GCC GCT TTA GTC CAC TCA GC-3′) and trnG-UCC (5′-GAA CGA ATC ACA CTT TTA CCA C) (Hamilton 1999). The *trnS-G*CU, trnG-UCC PCR reaction contained 2.5 µl 10X buffer, 0.438 µl 10 mM dNTPs, 0.625 µl 50 mM MgCl2, 0.25 units of Biolase *Taq* polymerase, and 0.54 µl of each primer (25mM). The PCR program consisted of a denaturing step for 4 minutes at 94°C, 35 amplification cycles of 45s at 94°C, 60s at 57°C, 80s at 72°C, and a final extension step of 6 minutes at 72°C in a Biorad MyCycler thermal cycler.

PCR products were verified prior to sequencing by using agarose gel electrophoresis; they were cleaned with ExoSAP (Exonuclease I and Shrimp Alkaline Phosphatase). The PCR product was prepared for sequencing by using the primers from PCR amplification and BigDye fluorescent dye-terminator reagent mix (Perkin-Elmer, Foster City, CA). Sequence reaction products were purified with Sephadex G-50 columns (GE Healthcare, Piscataway, NJ) to remove unincorporated dye terminators. Sequences were generated on an ABI 3100 automated sequencer (Applied Biosystems, Inc., Foster City, CA) in the Osher Molecular Lab at the Center for Comparative Genomics at the California Academy of Sciences.

Sequence alignment.— Sequences were manually edited in Sequencher 4.7 (Gene Codes Corp., Inc., Ann Arbor, MI). Rough alignments were performed in Sequencher 4.7 and ClustalX 1.83 (Thompson et al. 1997) and sequences were further aligned by eye in MacClade 4.08 (Maddison & Maddison 2005). The nrITS matrix was trimmed to include only the two spacers, ITS1 and ITS2, and the 5.8S RNA region. Sequences of nrITS could not be obtained for seven (about one-third) of the taxa, possibly due to the low quality of DNA in some of the herbarium specimens. The *trnS-G* sequence data for one taxon were not obtained, likely for the same reason.

Data congruence.— Congruence of the two data sets (nrITS and *trnS-G*) was tested using the partition homogeneity test (Farris et al. 1994, 1995) as implemented by PAUP* (Phylogenetic Analysis Using Parsimony) version 4.0b10 (Swofford 2002). To test for congruence, the two data sets were reduced to 14 taxa, i.e., they included only those taxa for which sequences of both regions were obtained. Parameters were set to 100 replicates and 5,000 maximum trees. The test found the two data sets to be congruent ($p = 0.12$), and further phylogenetic analyses were conducted for each region separately and in a combined data set.

Phylogenetic analyses.— Maximum parsimony (MP), maximum likelihood (ML), and Bayesian inference tests were conducted to create phylogenetic trees. Clade support was calculated by using bootstrap methods (Felsenstein 1985) for MP trees and Bayesian Posterior Probabilities (BPP) for ML and Bayesian trees.

MP analyses were performed in PAUP* by using branch and bound searches for single regions and a heuristic search for the combined data set. Characters were equally weighted and unordered, with gaps treated as missing data. Heuristic searches were run using 5,000 random replicates and TBR branch swapping. Bootstrap analyses for single region data sets were run using 1,000 replicates, TBR branch swapping, 10,000 max trees (5,000 in the combined analysis), and 10 random addition sequences per bootstrap replicate. Clades with a bootstrap value of > 90% were considered to have strong support, 80–90% moderate support, and < 80% weak support.

For the ML and Bayesian analyses, we used MrModeltest 2.2 (Nylander 2004) to find the best-fit model of nucleotide substitution. MrModeltest uses four different hierarchies to calculate the likelihood ratio between models (Posada & Crandall 2001). We then conducted the ML analyses in PAUP*, starting with a neighbor joining tree and using the parameters in the best-fit model chosen by the hierarchical likelihood test. Bayesian analyses were performed in MrBayes 3.1.2 (Huelsenbeck & Ronquist 2001; Ronquist & Huelsenbeck 2003). We used a separate best-fit model to represent each DNA region, then combined the two data sets, and implemented both models by partitioning the data. Two Markov chain Monte Carlo (MCMC) runs were performed, each with one cold chain and three heated chains for 5,000,000 generations, saving a tree every 1,000 generations. Likelihood scores were determined to be stationary at 345,000 generations (the "burn-in" point), and data prior to this point were discarded. Clades with Bayesian Posterior Probabilities > 95% were considered to have strong support, 90–95% moderate support, and < 90% weak support.

CONSTRAINT ANALYSIS.— An alternative phylogenetic hypothesis was evaluated using MacClade to create a tree that constrained the clade of interest. This tree was loaded into PAUP* as a constraint tree, where PAUP* used the maximum parsimony search criteria described above to find the shortest tree consistent with the new tree topology. The difference in length between the original and constrained trees provides an indication of the parsimony cost (additional steps) involved in accepting the alternative hypothesis.

PHYLOGEOGRAPHIC ANALYSES.— Ancestral areas for *Elytraria* were located using both Fitch optimization (Maddison et al. 1992) and dispersal-vicariance analysis (DIVA 1.1; Ronquist 1996, 1997). Fitch optimization is run in PAUP* and codes geographic area as a single multistate character that is treated as unordered. DIVA codes for presence/absence and uses each geographic area as a separate character. DIVA requires a fully resolved tree. For both of these analyses, a pruned version of the ML phylogeny shown in Figure 6 was used. To simplify the dataset, we included a single branch per species. Each taxon used in the analysis (with the exception of *E. imbricata*) was assigned to one of six geographic areas: Africa, Madagascar, Greater Antilles, southeastern USA, South America, and western USA/Mexico/Central America. These areas were chosen because most species of *Elytraria* are restricted to just one of them. *Elytraria imbricata* is the only species present in two areas, western USA/Mexico/Central and South America. Fitch optimization assumes dispersal as the only mode of speciation. DIVA finds the optimal ancestral area by assuming vicariance and penalizing for dispersal and extinction events. In DIVA, vicariance and duplication events carry a cost of zero, whereas dispersal and extinction events each carry a cost of one. Optimizations try to minimize the cost. For the DIVA analysis, we constrained the number of ancestral areas to include no more than two using the "maxareas" option. The number of maxareas was chosen on the basis of the maximum number of areas occupied by an extant species (Mansion & Struwe 2004; Oberprieler 2005).

RESULTS

SEQUENCE DATA.— Table 2 summarizes the sequence data characteristics for each genic region as well as the combined data set, and includes number of OTUs sequenced, aligned length, % GC content base frequencies, proportion of variable sites, proportion of parsimony informative sites, range of pairwise distances (for all taxa and for *Elytraria* only), MP analysis tree parameters, and each of the models chosen by MrModeltest and used in the ML and Bayesian analyses.

PHYLOGENETIC ANALYSES.— MP analysis of the *trnS-G* data set resulted in two equally most parsimonious trees. A strict consensus of these trees is moderately well resolved (Fig. 1). There is moderate to strong support for six clades: *Elytraria* (Bootstrap Support, BS = 97%), *E. imbricata* (BS = 88%), *E. imbricata* + *E. mexicana* (BS = 95%), *E. bromoides* (BS = 90%), *E. nodosa* (Madagascar) + *E. acaulis* (Malawi) (BS = 90%), and *Anisosepalum* + *Staurogyne* (BS = 98%). The relationships of other species within *Elytraria* and the relationships of the other genera of Nelsonioideae are poorly supported or are represented by polytomies. The *trnS-G* ML analysis yielded a similar tree (Fig. 2). The ML tree shows strong support for monophyly of *Elytraria* (BPP = 97%),

TABLE 2. Summary of sequence data characteristics for nrITS region, *trnS-G* spacer, and combined dataset. Search method used in maximum parsimony analyses: *branch and bound, **heuristic.

	nrITS	*trnS-G*	*combined dataset*
Number of OTUs	15	21	22
Aligned length	612	704	1316
% CG content	64.10%	30.00%	45.86%
Base frequencies			
A	0.194	0.385	0.296
C	0.33	0.136	0.226
G	0.311	0.164	0.232
T	0.165	0.315	0.245
Variable sites (proportion)	340 (0.556)	224 (0.318)	564 (0.429)
Parsimony informative sites (proportion)	163 (0.266)	72 (0.102)	235 (0.179)
Pairwise distances, all taxa (range, %)	0.2—33.8%	0.0—23.2%	0.1—25.5%
Pairwise distances, *Elytraria* only (range, %)	0.2—11.4%	0.0—3.7%	0.1—9.5%
Maximum parsimony analyses			
Number of most parsimonious trees found	1*	2*	20**
Length (all characters)	597	283	900
Length (parsimony informative characters)	383	118	512
Consistency index (parsimony informative characters)	0.674	0.678	0.668
Retention index (parsimony informative characters)	0.642	0.796	0.688
Maximum likelihood analyses			
Model chosen by MrModelTest	K80+G	HKY85+G	GTR+G
Bayesian analyses			
Model chosen by MrModelTest			HKY85+G

E. imbricata (BPP = 100%), *E. imbricata* + *E. mexicana* (BPP = 100%), *E. bromoides* (BPP = 100%), a "Greater Antilles" clade consisting of species of *Elytraria* from Cuba (*E. planifolia*) and Haiti (*E. prolifera*) (BPP = 95%), a "Gulf of Mexico" clade consisting of (*E. caroliniensis* + *E. macrophylla*) + "Greater Antilles" clade (BPP = 100%), *E. nodosa* (Madagascar) + *E. acaulis* (Malawi) (BPP = 100%), *E. nodosa* + two eastern African species (BPP = 97%), and *Anisosepalum* + *Staurogyne* (BPP = 100%). Strong support for a clade of African/Malagasy + "Gulf of Mexico" species of *Elytraria* (BPP = 97%) was recovered in this tree, but not in any other analysis. Bayesian analysis yielded a tree (not shown) almost identical to the ML tree, but with *E. marginata* sister to the "Gulf of Mexico" clade (BPP = 85%) instead of to the eastern African species of *Elytraria*.

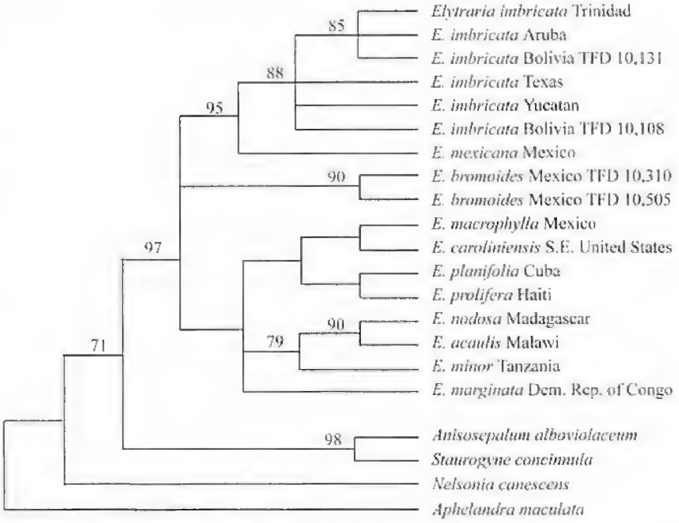


FIGURE 1. Strict consensus of two most parsimonious trees from a *trnS-G* branch and bound analysis. Values at nodes indicate bootstrap support > 70%. L = 597 (all characters), CI = 0.674, RI = 0.642.

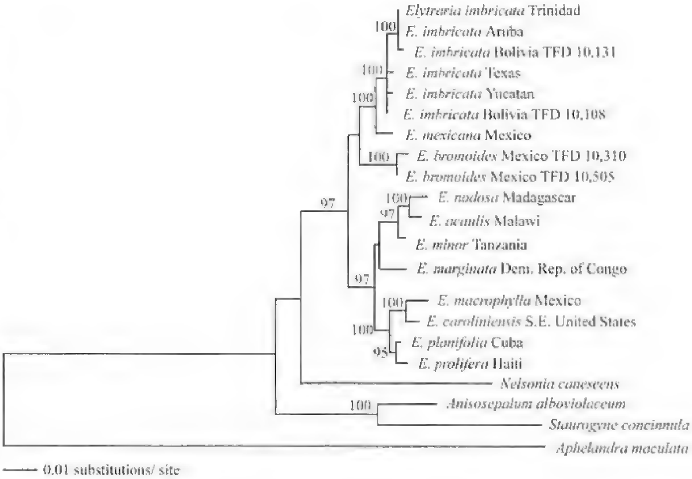


FIGURE 2. Maximum likelihood tree based on a *trnS-G* analysis using the K80+G model of evolution. Values at nodes indicate Bayesian posterior probabilities > 90%.

MP analysis of the nrITS data set resulted in a single, moderately well resolved tree (Fig. 3). There is strong support for monophyly of *Elytraria* (BS = 99%), the "Greater Antilles" clade (BS = 96%), *E. nodosa* + *E. acaulis* (BS = 100%), and *Ophiorrhiziphyllon* + *Staurogyne* (BS = 100%). All NW *Elytraria* form a clade sister to the eastern African/Malagasy clade (BS = 99%). The ML tree (Fig. 4) shows strong support for *Elytraria* (BPP = 100%), *E. imbricata* + *E. mexicana* (BPP = 100%), *E. nodosa* (Madagascar) + *E. acaulis* (Malawi) (BPP = 100%), NW *Elytraria* as sister to the eastern African/Malagasy clade (BPP = 100%), and *Ophiorrhiziphyllon* + *Staurogyne* (BPP = 99%). The Bayesian (not shown) and ML trees were nearly identical, except that *E. bromoides* formed an unsupported clade together with *E. planifolia* and *E. prolifera* in the former tree.

MP analysis of the combined nrITS + *trnS-G* data set resulted in 20 equally most parsimonious trees. A strict consensus of these trees (Fig. 5) is similar to the nrITS MP tree (Fig. 3), but less well resolved due to multiple collapsed branches. This tree shows moderate to strong BS support for eight clades: *Elytraria* (BS = 99%), *E. imbricata* + *E. mexicana* (BS = 98%), *E. bromoides* (BS = 87%), the "Greater Antilles" clade (BS = 98%), *E. nodosa* + *E. acaulis* (BS = 92%), *E. nodosa* + two eastern African species (BS = 80%), *Ophiorrhiziphyllon* + *Staurogyne* (BS = 100%), and *Ophiorrhiziphyllon* + *Staurogyne* + *Anisosepalum* (BS = 84%). The combined ML tree (Fig. 6) is identical to the Bayesian tree (not shown), except for the placement of *Nelsonia*, which has no BPP support. The ML tree shows strong BPP support for all eight clades supported in the MP analysis: *Elytraria* (BPP = 100%), *E. imbricata* + *E. mexicana* (BPP = 100%), *E. bromoides* (BPP = 100%), the "Greater Antilles" clade (BPP = 100%), *E. nodosa* + *E. acaulis* (BPP = 100%), *E. nodosa* + two eastern African species (BPP = 97%), *Ophiorrhiziphyllon* + *Staurogyne* (BPP = 100%), and (*Ophiorrhiziphyllon* + *Staurogyne*) *Anisosepalum* (BPP = 100%). BPP values also add strong support for the "Gulf of Mexico" clade (BPP = 99%), an eastern African/Malagasy clade (BPP = 97%), NW *Elytraria* (BPP = 98%), and NW *Elytraria* + western/central African *Elytraria* (BPP = 99%). The eastern African/Malagasy clade is basal in the genus.

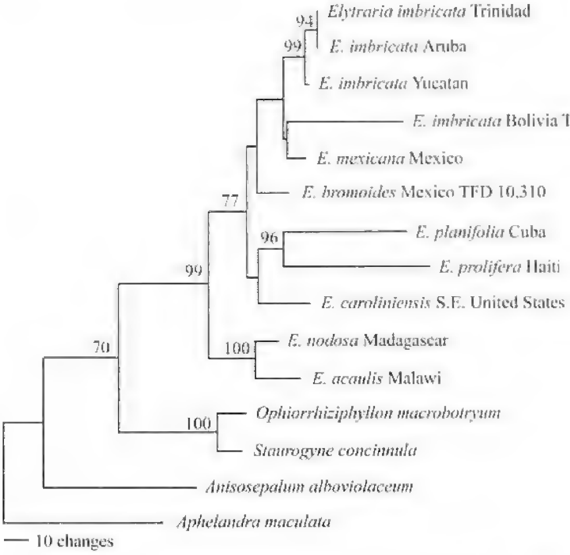


FIGURE 3. Single most parsimonious tree resulting from a nrITS branch and bound analysis. Values at nodes indicate bootstrap support > 70%. L = 283 (all characters), CI = 0.678, RI = 0.796.

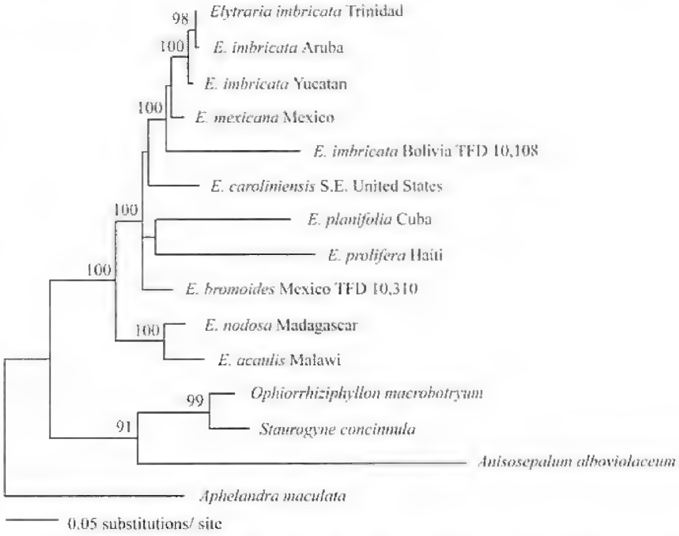


FIGURE 4. Maximum likelihood tree based on a nrITS analysis using the HKY+G model of evolution. Values at nodes indicate Bayesian posterior probabilities > 90%.

PHYLOGEOGRAPHIC ANALYSES.— Fitch parsimony optimization resulted in an optimization tree (Fig. 7) of five steps (dispersals), with the basal node ancestral area being scored unambiguously as Africa. A single trans-Atlantic dispersal event occurred from Africa to western USA/Mexico/Central America, and from there dispersals occurred to the southeastern USA, the Greater Antilles, and South America. There was also a dispersal event from Africa to Madagascar.

The DIVA reconstruction (Fig. 8) yielded two alternative ancestral areas for the basal node. One scenario identifies an ancestral area of Africa with a subsequent dispersal event to western USA/Mexico/Central America. The other scenario identifies a vicariance event with an ancestral area of Africa and western USA/Mexico/Central America. DIVA identified five dispersal events, four to five vicariance events, and five to six duplication events, with the number of vicariance and duplication events depending on the ancestral area of the basal node.

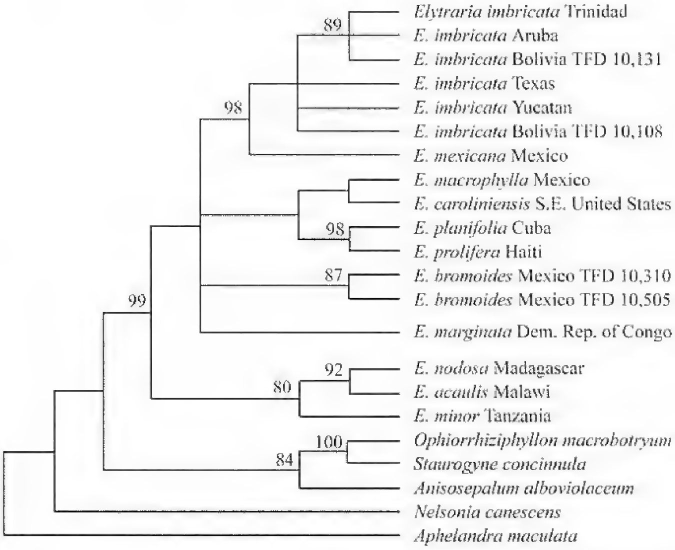

89
98
98
87
99
92
80
100
84
Elytraria imbricata Trinidad
E. imbricata Aruba
E. imbricata Bolivia TFD 10,131
E. imbricata Texas
E. imbricata Yucatan
E. imbricata Bolivia TFD 10,108
E. mexicana Mexico
E. macrophylla Mexico
E. caroliniensis S.E. United States
E. planifolia Cuba
E. prolifera Haiti
E. bromoides Mexico TFD 10,310
E. bromoides Mexico TFD 10,505
E. marginata Dem. Rep. of Congo
E. nodosa Madagascar
E. acaulis Malawi
E. minor Tanzania
Ophiorrhiziphyllon macrobotryum
Staurogyne concinnula
Anisosepalum alboviolaceum
Nelsonia canescens
Aphelandra maculata

FIGURE 5. Strict consensus of 20 most parsimonious trees from a combined *trnS-G* and nrITS heuristic analysis. Values at nodes indicate bootstrap support > 70%. L = 900 (all characters), CI = 0.668, RI = 0.688.

DISCUSSION

Molecular Phylogenetics

RELATIONSHIPS OF GENERA OF NELSONIOIDEAE.— From our analyses of samples from five of the seven genera of Nelsonioideae, a lineage consisting of *Staurogyne*, *Ophiorrhiziphyllon*, and *Anisosepalum* is recovered in both combined analyses (e.g., Fig. 6, BPP = 100%). Hossain (1971) hypothesized that based on morphological characters (e.g., calyx five-partite), these three "staurogynoid" genera (plus *Gynocraterium* and *Saintpauliopsis*, neither of which were included in our analyses) are more closely related to each other than to *Elytraria* and *Nelsonia* (both of which have the calyx four-partite with the posterior lobe incompletely fused). Indeed, several species of *Anisosepalum* were originally described in *Staurogyne*, and *Ophiorrhiziphyllon* differs from *Staurogyne* in rather minor characters (e.g., smaller connective between anther thecae, stamens long-exserted vs. included or slightly exserted in *Staurogyne*, and thecae elongate vs. subglobose to globose in *Staurogyne*).

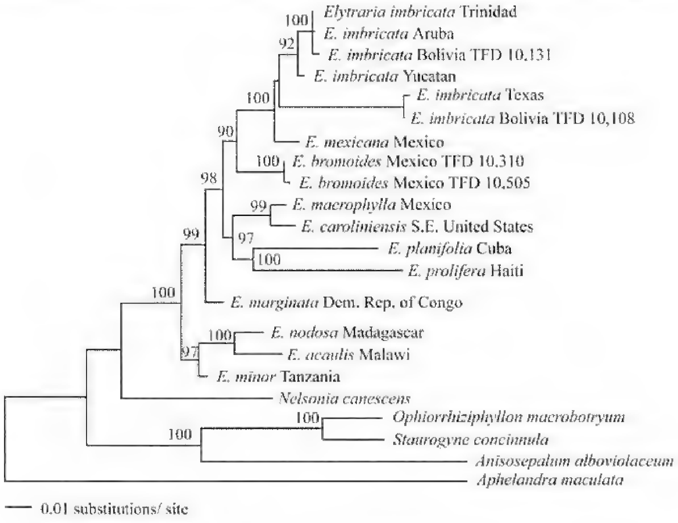


FIGURE 6. Maximum likelihood tree based on a combined *trnS-G* and nrITS analysis using the GTR+G model of evolution. Values at nodes indicate Bayesian posterior probabilities > 90%.

Additional sampling should reveal whether *Staurogyne* should be treated more broadly so as to include some or all of the four other genera either known or hypothesized to be closely related to it.

Hossain (1971) indicated that *Nelsonia* and *Elytraria* were morphologically distinct from the "staurogynoid" genera of Nelsonioideae. Our analyses usually place *Nelsonia* separate from either *Elytraria* or the "staurogynoid" genera, but are unable to establish its topologic position relative to these other nelsonioid clades. Morphologically, *Nelsonia* shares some characters with *Elytraria* (e.g., inflorescences of dense spikes bearing alternate to spirally arranged bracts), other characters with the "staurogynoid" genera (e.g., hooklike projections on the seeds), and some characters unique to the subfamily (e.g., absence of bracteoles). Divergent taxonomies of *Nelsonia* have been proposed with the number of species varying from one (Hossain 1984) to five (Vollesen 1994). Additional sampling will enable testing for monophyly of that genus, infrageneric relationships, and its placement within Nelsonioideae.

MONOPHYLY OF *ELYTRARIA*.— All phylogenetic analyses strongly support monophyly of *Elytraria* (BS = 97-99%, BPP = 97-100%). On the basis of morphological characters, *Elytraria* has been recognized for more than 150 years (Nees 1847) as a cohesive taxon that occurs on multiple continents in both the OW and the

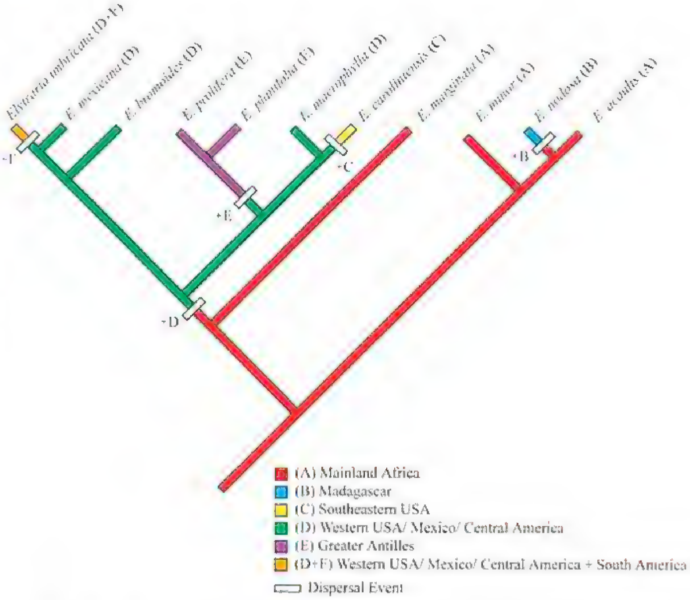


FIGURE 7. Fitch optimization tree showing five dispersal events. Area designations (in parentheses): (A) Mainland Africa, (B) Madagascar, (C) Southeastern USA, (D) Western USA/Mexico/Central America, (E) Greater Antilles, (F) South America.

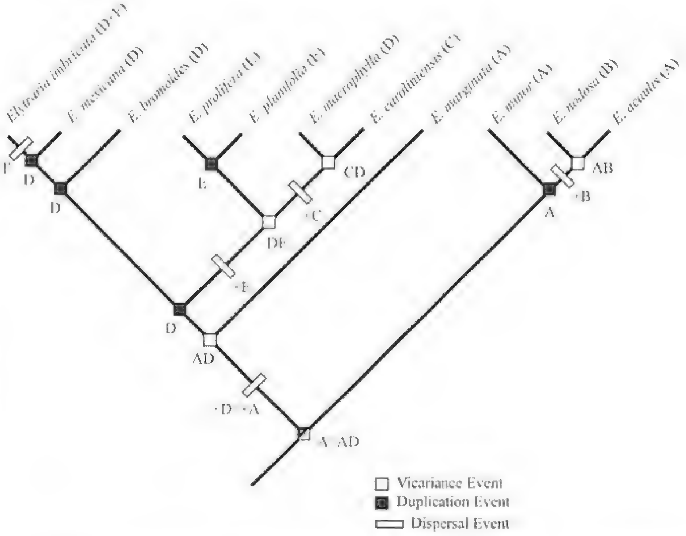


FIGURE 8. Ancestral area reconstruction based on DIVA, using a pruned tree from the ML analysis of the combined dataset. DIVA set to maxareas = 2. Area designations (in parentheses): (A) Mainland Africa, (B) Madagascar, (C) Southeastern USA, (D) Western USA/Mexico/Central America, (E) Greater Antilles, (F) South America. Ancestral areas separated by a slash represent equally parsimonious reconstructions. Results include 4—5 vicariance events (allopatric speciation), 5—6 duplication events (sympatric speciation), and 5 dispersal events, depending on basal node reconstruction.

NW. These characters include: 1) inflorescence peduncles (scapes) covered with alternate to spirally arranged scales (probable synapomophy), 2) four-partite calyx with anterior lobe bifid to bilobed (symplesiomorphy; shared with *Nelsonia*), 3) seeds lacking minute hooklike projections (probable symplesiomorphy; shared with *Anisosepalum*), and 4) touch-sensitive stigma (probable synapomorphy). Molecular data now confirm the taxonomic delimitation of *Elytraria*, and show that the morphological characters coincide with the phylogeny recovered in our analyses.

INFRAGENERIC RELATIONSHIPS OF *ELYTRARIA* AND MONOPHYLY OF *E. IMBRICATA*.— *Elytraria* consists of 22 species that occur in tropical, subtropical, and temperate regions (Appendix 2). Concentrations of species are found in tropical Africa (six species; Dokosi 1979), Cuba (6 species; Borhidi and Muñiz 1977; Dietrich 1982), and Mexico (4 species; Daniel and Acosta C. 2003). Hossain (1971, 1972) divided *Elytraria* into two subgenera. Subgenus *Tetrandra* consists of the two species (*E. madagascariensis* and *E. nodosa*) endemic to Madagascar; subgenus *Elytraria* includes all of the other taxa. Morphologically, the Malagasy species are unique in *Elytraria* by having four (vs. two) fertile stamens and an anther connective with (vs. without) an apical appendage. Comparing morphological and anatomical characters of these two species to others of *Elytraria*, as well as to other nelsonioid genera, Hossain (1971, 1972) hypothesized that many of the characteristics of subgenus *Tetrandra* are primitive within *Elytraria*. Specifically, he noted the probable reduction of stamens from four to two in the genus. Among extant nelsonioids, androecial elements consist of two fertile stamens and no staminodes (*Nelsonia* and some *Elytraria*), two fertile stamens and one or more staminodes (*Ophiorrhiziphyllon*, most *Elytraria*, and some *Staurogyne*), and four fertile stamens with zero or one staminode (*Anisosepalum*, *Gynocraterium*, *Saintpauliopsis*, most *Staurogyne*, and the two Malagasy *Elytraria*). Combined molecular phylogenetic analyses place the Malagasy endemic, *E. nodosa*, in a moderately or strongly supported clade together with two species from eastern Africa (Fig. 5, BS = 80%; Fig. 6, BPP = 97%), at the base of the genus. On the basis of this topology, Hossain's hypothesis that many characters of subgenus *Tetrandra* are primitive (specifically the number of stamens) is not supported. Also, topologies of the trees obtained in this study do not support recognition of two monophyletic subgenera as treated by Hossain. However, based on morphological characters, the two Malagasy endemics would indeed appear to represent closely related species worthy of infrageneric recognition.

The combined ML analysis (Fig. 6) reveals that the OW species of *Elytraria* do not form a monophyletic group. Indeed, the central to western African species *E. marginata* is strongly supported as sister to the NW clade of the genus in this analysis (Fig. 6, BPP = 99%). In both MP and ML analyses, a clade consisting of the eastern African species and *E. nodosa* from Madagascar are supported as monophyletic (Fig. 5, BS = 80%; Fig. 6, BPP = 97%) and strongly supported as sister to NW *Elytraria* + *E. marginata* (Fig. 5, BS = 99%; Fig. 6, BPP = 100%). Constraining OW *Elytraria* to monophyly by altering the placement of *E. marginata* in our combined MP tree (Fig. 5) requires only two additional steps (L=900 vs. 902). The constraint analysis suggests that monophyly of OW *Elytraria* cannot be rejected by our data. The taxonomy of OW species has yet to be fully resolved and our samples do not include any plants from Asia (i.e., *E. acaulis* from India and Sri Lanka).

In the combined ML analysis, the NW species of *Elytraria* form a strongly supported clade (Fig. 6, BPP = 98%), but this clade is not supported in the MP analyses. The topologic positions of three oft recovered NW lineages: *E. imbricata* + *E. mexicana*, *E. bromoides*, and the "Gulf of Mexico" clade, vary in each of the analyses. Moderate to strong support for a monophyletic *E. imbricata* is shown only in the *trnS-G* phylogenies (Fig. 1, BS = 88%; Fig. 2, BPP = 100%), which have *E. mexicana* as sister to *E. imbricata*. When the nrITS data is added, a monophyletic *E. imbricata* either has no support (Figs. 5, 6), or *E. mexicana* is placed within *E. imbricata* (Figs. 3, 4). *Ely-*

traria mexicana is known only from semi-arid regions of central and western Mexico (Daniel & Acosta C. 2003), within the range of *E. imbricata*. Morphologically, these species appear to be very similar; they differ primarily in characters of the bracteal apex (acuminate-spinose in *E. mexicana* vs. prominently 3-parted, at least among distal bracts, in *E. imbricata*), bracteal pubescence (abaxially villous in *E. mexicana* vs. abaxially usually glabrous in *E. imbricata*), and color of the corolla limb (whitish with dark purple markings on the lobes of the upper lip in *E. mexicana* vs. blue with white and yellow markings on the lower lip or rarely entirely white in *E. imbricata*). The morphological distinctions and taxonomic status of these two species are currently being reevaluated; however, our results substantiate a close relationship between them.

Phylogeography

Distributions of Nelsonioideae.— Genera of Nelsonioideae exhibit diverse patterns of present-day distribution (Table 1). The largest genus, *Staurogyne*, has concentrations of species in South America, Africa, and Asia; a few species also occur in southern North America and northern Australia. Close relatives of *Staurogyne*, both known (*Anisosepalum* and *Ophiorrhiziphyllon*) and suspected (*Gynocraterium* and *Saintpauliopsis*), are restricted to areas with significant concentrations of species of that genus. *Nelsonia* is pantropical with native occurrences in Africa, Madagascar, Asia, Australia, and possibly the NW (Hossain 1971; Vollesen 1994). *Elytraria* appears to be particularly widespread in both the OW and NW tropics, with several NW species either extending their ranges into (e.g., *E. bromoides*, *E. imbricata*) or endemic to (e.g., *E. caroliniensis*) temperate regions.

Area of origin and dispersal of Elytraria.— DIVA provides two alternative ancestral areas, either Africa or Africa and western USA/Mexico/Central America. Fitch optimization results in an ancestral area of Africa, with a single dispersal event to the New World, from western or central Africa across the Atlantic Ocean. Because both analyses include an optimization of Africa at the ancestral node of *Elytraria*, most evidence supports Africa as the area of origin for this genus. Because available evidence and analyses to date (see McDade et al. 2005, 2008) establish that Acanthaceae evolved subsequent to the breakup of the Gondwanan landmass, dispersal is the most appropriate explanation for intercontinental disjunctions. Most recent phylogenetic studies on other clades of Acanthaceae have revealed an OW origin followed by a single dispersal event to the NW with subsequent diversification there (i.e., Acantheae, McDade et al. 2005; Isoglossinae, Kiel et al. 2006; *Tetramerium* lineage of Justicieae, Daniel et al. 2008; Thunbergioideae, Borg et al. 2008). Our results suggest a similar scenario for *Elytraria* as well.

Renner (2004) studied the mechanisms for plant dispersal across the tropical Atlantic. Wind, birds, water, and floating rafts of vegetation are all possible mechanisms of trans-oceanic dispersal. Strong east-to-west surface winds rarely make it across the entire central Atlantic, although Saharan dust does occasionally make it to the New World (Renner 2004). Seeds of *Elytraria* are small (between 0.3 and 1.0 mm in diameter), but lack attributes (e.g., wings) that might make them candidates for wind dispersal. Seeds of *Elytraria* may have been transported across the ocean by sticking to mud on the feet of birds. Today there are no avian species that have tropical trans-Atlantic migration routes (Renner 2004), though a few sea birds are carried from West Africa across the Atlantic to North America by tropical storms (Rappole et al. 2000). Bird transportation remains a possible, though unlikely, mode of trans-Atlantic dispersal for *Elytraria*.

Oceanic surface water currents influence the last two modes of dispersal under consideration: water and rafting. Today's patterns of oceanic surface currents have changed little since the end of the Late Cretaceous (Parrish 1993). Currents in the northern South Atlantic are primarily determined by the placement of the continents, and modern day ocean circulation patterns are thought to have arisen shortly after the formation of the South Atlantic (Parrish 1993). Today, currents are predominantly east-to-west, with a single west-to-east current that originates well offshore (Renner 2004).

The small size and unprotected coating of seeds of *Elytraria* render them unlikely to survive in salt water for prolonged periods of time. A raft of vegetation carrying seeds or entire plants provides the best explanation for the present day distribution of *Elytraria* in both the OW and the NW. Equatorial currents can transport large mats of vegetation coming out of the mouths of the Niger and Congo Rivers across the Atlantic Ocean in less than two weeks (Renner 2004; Measey et al. 2007). There is evidence suggesting that east-to-west trans-Atlantic rafting events may account for dispersal in multiple plant and animal groups (Carranza et al. 2000; Cronn and Wendel 2004; Vidal et al. 2008).

While the amphi-Atlantic distribution of *Elytraria* can be explained by a single oceanic dispersal event, several shorter dispersals must also have taken place to account for its multiple insular occurrences. Two species of *Elytraria*, *E. nodosa* and *E. madagascariensis*, are endemic to the island of Madagascar. These species share several morphological characters not found in any other species of *Elytraria* (see above), and can be assumed to be sister species based on these putative synapomorphies. All molecular phylogenetic analyses strongly support placing *E. nodosa* sister to *E. acaulis* from eastern Africa (e.g., Fig. 5, BS = 92%; Fig. 6, BPP = 100%), suggesting a single dispersal event to the island from eastern Africa. Madagascar lies 400 km off the eastern coast of Africa and has maintained this position relative to the mainland for the last 120–130 my (Rabinowitz & Woods 2006). Rabinowitz & Woods (2006) found that the assumption of previous studies supporting the exposure of dry land in the Mozambique Channel, connecting Madagascar to the mainland, to be incorrect. Rather, they found that it is unlikely there has been any land exposure since before the middle Eocene (50 mya), when the first mammals migrated to Madagascar. Rabinowitz & Woods (2006) hypothesized that the early mammals probably arrived by swimming or by floating on vegetation mats, the most likely method for dispersal of *Elytraria* there as well.

Island dispersal has also occurred in the Gulf of Guinea, where the widespread West African *Elytraria marginata* is found on the islands of São Tomé and Príncipe. These oceanic islands are part of the Cameroon Line of volcanoes and lie over 200 km from the mainland. With ages of at least 13 and 31 million years (Lee et al. 1994), respectively, São Tomé and Príncipe have never been connected to continental Africa (Jones 1994). Measey et al. (2007) propose that the colonization of São Tomé by amphibians was via rafting events. Major sea surface currents in the Gulf of Guinea would carry any rafts of debris from the Niger and Congo rivers directly towards São Tomé, making rafting a plausible explanation for the dispersal of *Elytraria* to these islands.

In the Caribbean Sea, *Elytraria* occurs on several islands. In some cases, dispersals have led to the formation of new species (e.g., Cuba and Hispaniola); in other cases, insular occurrences of *E. imbricata* likely result from recent colonizations or persistence of the species on islands previously connected to the American mainland during periods of lower sea levels (e.g., Trinidad, Tobago, Bonaire, Curaçao, Isla San Andrés).

Future Studies

These preliminary findings address phylogenetic relationships of several constituent genera of Nelsonioideae, relationships of species in *Elytraria*, and biogeographic patterns based on the phylogenies recovered. Relationships of the seven genera of Nelsonioideae remain unresolved due to weak or no support in the lower branches of the trees and absence of data for some genera

(*Gynocraterium* and *Saintpauliopsis*). Future studies on Nelsonioideae will include additional field and herbarium work in order to obtain collections of more taxa (i.e., species of *Elytraria* and other genera of Nelsonioideae), and will add sequences from additional genic regions. These additions should result in more comprehensive and better resolved trees that can further address taxonomic composition and monophyly of the subfamily, whether "staurogynoid" genera should be treated in a broader *Staurogyne*, the infrageneric classification of *Staurogyne* proposed by Hossain (1971), and phylogeography of the entire subfamily. Phylogeography of this basal lineage of Acanthaceae should be particularly revealing because the distribution patterns of extant genera common to both the OW and the NW (*Elytraria*, *Nelsonia*, and *Staurogyne*) suggest a more dynamic history of intercontinental dispersals than is known for other lineages of Acanthaceae studied to date.

ACKNOWLEDGMENTS

This study represents a portion of a Master of Science thesis from San Francisco State University by the first author. Molecular sequencing was supported by the SFSU Biology Department IRA Research Grant. Wenk's travel to meetings was funded by the SFSU Graduate Student Council in Biology Travel Grants and the Department of Botany at the California Academy of Sciences. Daniel's studies of *Elytraria* were supported, in part, by a grant from the National Science Foundation (DEB-0743273). We thank A. Carmichael, F. Cipriano, B. Cruz, K. Deiner, M. Flannery, P. Fritsch, W.B. Simison, and G. Spicer for help with molecular sequencing and phylogenetic analyses. Also, we thank F. Almeda, D. Champluvier, J.L. Clark, and L. McDade for providing DNA samples. We are grateful to the following herbaria for allowing us to borrow specimens for morphological studies and/or DNA sampling: A, BR, CAS, DS, F, GH, MO, NY, P, S, UC, and US.

LITERATURE CITED

BORG, A.J., L.A. MCDADE, AND J. SCHÖNENBERGER. 2008. Molecular phylogenetics and morphological evolution of Thunbergioideae (Acanthaceae). *Taxon* 57:811–822.

BORHIDI, A. AND O. MUÑIZ. 1977. Notas Sobre Acantáceas Cubanas I. *Oplonia* y *Elytraria*. *Acta Botanica Academiae Scientientiarum Hungaricae* 23:303–317.

BREMEKAMP, C.E.B. 1953. The delimitation of Acanthaceae. *Proceedings of the Koninklijke Nederlandse Academie van Wetenschappen. Series C: Biological and Medical Sciences* 56:533–546.

BREMEKAMP, C.E.B. 1965. Delimitation and subdivision of the Acanthaceae. *Bulletin of the Botanical Survey of India* 7:21–30.

CARRANZA S., E. N. ARNOLD, J. A. MATEO, AND L. F. LOPEZ-JURADO. 2000. Long-distance colonization and radiation in gekkonid lizards, *Tarentola* (Reptilia: Gekkonidae), revealed by mitochondrial DNA sequences. *Proceedings pf the Royal Society of London, Series B: Biological Sciences* 267:637–649.

CRONN, R. AND J.F. WENDEL. 2004. Cryptic trysts, genomic mergers, and plant speciation. *New Phytologist* 161:133–142.

DANIEL, T.F. AND S. ACOSTA C. 2003. Acanthaceae. Pages 1–173 *in* J. Rzedowski and G. Calderon de Rzedowski, eds., *Flora del Bajío y de Regiones Adyacentes*, Fascículo 117. Instituto de Ecología, Centro Regional del Bajío, Pátzcuaro, Mexico.

DANIEL, T.F., L.A. MCDADE, M. MANKTELOW, AND C.A. KIEL. 2008. The "*Tetramerium*" lineage (Acanthaceae: Acanthoideae: Justicieae): delimitation and intra-lineage relationships based on cp and nrITS sequence data. *Systematic Botany* 33:416–436.

DIETRICH, H. 1982. Acanthaceae Cubanae Novae I. *Elytraria bissei* H. Dietrich, spec. nov. *Revista del Jardín Botánico Nacional (Habana)* 3(2):39–51.

DOKOSI, O.B. 1979. A new species of *Elytraria* (Acanthaceae) occurring in East Africa. *Adansonia* 18:433–441.

FARRIS, J.S., M. KÄLLERSJÖ, A.G. KLUGE, AND C. BULT. 1994. Testing significance of incongruence. *Cladistics* 10:315–319.

FARRIS, J.S., M. KÄLLERSJÖ, A.G. KLUGE, AND C. BULT. 1995. Constructing a significance test for incongruence. *Systematic Biology* 44:570–572.

FELSENSTEIN, J. 1985. Confidence limits on phylogenetics: an approach using the bootstrap. *Evolution* 39:783–791.

HAMILTON, M.B. 1999. Four primer pairs for the amplification of chloroplast intergenic regions with intraspecific variation. *Molecular Ecology* 8:521–523.

HEDRÉN, M., M.W. CHASE, AND R.G. OLMSTEAD. 1995. Relationships in the Acanthaceae and related families as suggested by cladistic analysis of *rbcL* nucleotide sequences. *Plant Systematics and Evolution* 194:93–109.

HOLMGREN, P.K., N.H. HOLMGREN, AND L.C. BARNETT. 1990. Index herbariorum, part I: the herbaria of the world. *Regnum Vegetabile* 120:1–693.

HOSSAIN, A.B.M.E. 1971. *Studies in the Classification and Affinities of Acanthaceae.* Ph.D. Dissertation, University of Edinburgh, United Kingdom.

HOSSAIN, A.B.M.E. 1972. Studies in Acanthaceae tribe Nelsonieae I: new and re-named taxa. *Notes from the Royal Botanic Garden, Edinburgh* 31:377–388.

HOSSAIN, A.B.M.E. 1984. Taxonomic notes on the *Nelsonia canescens* complex (Acanthaceae). *Willdenowia* 14:397–403.

HUELSENBECK, J. P. AND F. RONQUIST. 2001. MRBAYES: Bayesian inference of phylogeny. *Bioinformatics* 17:754–755.

JONES, P.J. 1994. Biodiversity in the Gulf of Guinea: an overview. *Biodiversity and Conservation* 3:772–785.

KIEL, C.A., L.A. MCDADE, T.F. DANIEL, AND D. CHAMPLUVIER. 2006. Phylogenetic delimitation of Isoglossinae (Acanthaceae: Justicieae) and relationships among constituent genera. *Taxon* 55:683–694.

LEE, D.-C., A.N. HALLIDAY, J.G. FITTON, AND G. POLI. 1994. Isotopic variations with distance and time in the volcanic islands of the Cameroon line: evidence for a mantle plume origin. *Earth and Planetary Science Letters* 123:119–138.

LINDAU, G. 1895. Acanthaceae. Pages 274–353 *in* A. Engler and K. Prantl, eds., *Die natürlichen Planzenfamilien* Vol. 4 (3b). Engelmann, Leipzig, Germany.

LU AN-MING. 1990. A preliminary cladistic study of the families of the superorder Lamiiflorae. *Botanical Journal of the Linnean Society* 103:39–57.

MADDISON, D.R. AND W.P. MADDISON. 2005. MacClade 4: Analysis of Phylogeny and Character Evolution. Version 4.08. Sinauer, Sunderland, Massachusetts, USA.

MADDISON, D.R., M. RUVOLO, AND D.L. SWOFFORD. 1992. Geographic origins of human mitochondrial DNA: phylogenetic evidence from control region sequences. *Systematic Biology* 41:111–124.

MANKTELOW, M., L.A. MCDADE, B. OXELMAN, C.A. FURNESS, AND M.-J. BALKWILL. 2001. The enigmatic tribe Whitfieldieae (Acanthaceae): delimitation and phylogenetic relationships based on molecular and morphological data. *Systematic Botany* 26:104–119.

MANSION, G. AND L. STRUWE. 2004. Generic delimitation and phylogenetic relationships within the subtribe Chironiinae (Chironieae: Gentianaceae), with special reference to *Centaurium*: evidence from nrDNA and cpDNA sequences. *Molecular Phylogenetics and Evolution* 32:951–977.

MCDADE, L.A., T.F. DANIEL, C.A. KIEL, AND K. VOLLESEN. 2005. Phylogenetic relationships among Acantheae (Acanthaceae): major lineages present contrasting patterns of molecular evolution and morphological differentiation. *Systematic Botany* 30:834–862.

MCDADE, L.A., T.F. DANIEL, AND C.A. KIEL. 2008. Toward a comprehensive understanding of phylogenetic relationships among lineages of Acanthaceae s.l. (Lamiales). *American Journal of Botany* 95:1136–1152.

MCDADE, L.A., S.E. MASTA, M.L. MOODY, AND E. WATERS. 2000. Phylogenetic relationships among Acanthaceae: evidence from two genomes. *Systematic Botany* 25:106–121.

MEASEY, G.J., M. VENCES, R.C. DREWES, Y. CHIARI, M. MELO, AND B. BOURLES. 2007. Freshwater paths across the ocean: molecular phylogeny of the frog *Ptychadena newtoni* gives insights into amphibian colonization of oceanic islands. *Journal of Biogeography* 34:7–20.

NEES VON ESENBECK, C.G.D. 1847. Acanthaceae. Pages 46–519 *in* A. de Candolle, ed., *Prodromus Systematis*

Naturalis Regni Vegetablis, vol. 11. V. Masson, Paris, France.

Nylander, J.A.A. 2004. MrModeltest v2. Program distributed by the author. Evolutionary Biology Centre, Uppsala University, Sweden.

Oberprieler, C. 2005. Temporal and spatial diversification of circum-Mediterranean Compositae-Anthemideae. *Taxon* 54:951–966.

Parrish, J.T. 1993. The palaeogeography of the opening of the South Atlantic. Pages 8–27 *in* W. George and R. Lavocat, eds., *The Africa-South America Connection*. Clarendon Press, Oxford, United Kingdom.

Posada, D. and K.A. Crandall. 2001. Selecting the best-fit model of nucleotide substitution. *Systematic Biology* 50:580–601

Rabinowitz, P.D. and S. Woods. 2006. The Africa-Madagascar connection and mammalian migrations. *Journal of African Earth Sciences* 44:270–276.

Rappole, J.H., S.R. Derrickson, and Z. Hubálek. 2000. Migratory birds and the spread of West Nile virus in the Western Hemisphere. *Emerging Infection Diseases* 6:319-328.

Renner, S. 2004. Plant dispersal across the tropical Atlantic by wind and sea currents. *International Journal of Plant Science* 165(4 Suppl.):S23–S33.

Ronquist, F. 1996. DIVA version 1.1. Computer program and manual available by anonymous FTP from Uppsala University (ftp.uu.se or ftp.systbot.uu.se).

Ronquist, F. 1997. Dispersal-vicariance analysis: A new approach to the quantification of historical biogeography. *Systematic Biology* 46:195–203.

Ronquist, F. and J.P. Huelsenbeck. 2003. MRBAYES 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics* 19:1572–1574.

Scotland, R.W. and K. Vollesen. 2000. Classification of Acanthaceae. *Kew Bulletin* 55:513–589.

Scotland, R.W., J.A. Sweere, P.A. Reeves, and R.G. Olmstead. 1995. Higher-level systematics of Acanthaceae determined by chloroplast DNA sequences. *American Journal of Botany* 82:266–275.

Sreemadhavan, C.P. 1977. Diagnosis of some new taxa and some new combinations in Bignoniales. *Phytologia* 37:412–416.

Swofford, D.L. 2002. PAUP*. Phylogenetic Analysis Using Parsimony (*and Other Methods). Version 4b10. Sinauer Associates, Sunderland, Massachusetts, USA.

Thompson, J.D., T.J. Gibson, F. Plewniak, F. Jeanmougin, and D.G. Higgins. 1997. The ClustalX windows interface: flexible strategies for multiple alignment aided by quality analysis tools. *Nucleic Acids Research* 25:4876–4882.

Vidal, N., A. Azvolinsky, C. Cruaud, and S.B. Hedges. 2008. Origin of tropical American burrowing reptiles by transatlantic rafting. *Biology Letters* 4:115–118.

Vollesen, K. 1994. Taxonomy, ecology and distribution of *Nelsonia* (Acanthaceae) in Africa. Pages 315–325 *in* J.H. Seyani and A.C. Chikuni, eds., *Proceedings of the XIIIth Plenary Meeting AETFAT*, Malawi.

Wen, J. and E.A. Zimmer. 1996. Phylogeny and biogeography of *Panax* L. (the ginseng genus, Araliaceae): inference from ITS sequences on nuclear ribosomal DNA. *Molecular Phylogenetics and Evolution* 6:167–177.

White, T.J., T. Bruns, S. Lee, and J. Taylor. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. Pages 315–322 *in* M.A. Innis, D.H. Gelfand, J.J. Sninsky, and T.J. White, eds., *PCR Protocols: A Guide to Methods and Applications*. Academic Press, Inc., San Diego, California, USA.

Appendix I

Taxa, GenBank accession numbers (trnS-G, nrITS; — = sequence not obtained), sources of plant materials from which DNA was extracted for sequencing, and type of material used for sequencing (herbarium specimen = H vs. silica-dried sample = S). Cultivated plants include native range in parentheses. Abbreviations for herbaria follow Holmgren et al. (1990). Taxa are listed in alphabetical order by genus and species.

Anisosepalum alboviolaceum (R. Ben.) E. Hossain; FJ868921, FJ868907; Champluvier 5,295 (CAS); Mbomo, Congo; H. Aphelandra maculata (Tafalla ex Nees) Voss; DQ059281, DQ028451, sequences downloaded from GenBank. Elytraria acaulis Lindau; FJ868940, FJ868920; Goyoler & Paton 3,520 (BR); Malawi; H. Elytraria bromoides Oerst.; FJ868929, FJ868914; T.F. Daniel 10,310 (CAS); Yucatán, Mexico; S. Elytraria bromoides Oerst.; FJ868930, —; T.F. Daniel 10,505 (CAS); Yucatán, Mexico; S. Elytraria caroliniensis (J.F. Gmel.) Pers.; FJ868936, FJ868918; 19712929-00cv, cultivated at BR (southeastern United States); S. Elytraria imbricata (Vahl) Pers.; FJ868928, FJ868913; T.F. Daniel 10,108 (CAS); Santa Cruz, Bolivia; S. Elytraria imbricata (Vahl) Pers.; FJ868927, —; T.F. Daniel 10,131 (CAS); Santa Cruz, Bolivia; S. Elytraria imbricata (Vahl) Pers.; FJ868924, FJ868910; T.F. Daniel 10,501 (CAS); Yucatán, Mexico; S. Elytraria imbricata (Vahl) Pers.; FJ868925, FJ868911; T.F. Daniel s.n. (CAS); Trinidad; S. Elytraria imbricata (Vahl) Pers.; FJ868923, —; E.J. Lott 5,175 (CAS); Texas, United States; H. Elytraria imbricata (Vahl) Pers.; FJ898626, FJ868912; Van Proosij et al. 719 (NY); Paradera, Aruba; H. Elytraria macrophylla Leonard; FJ868933, —; Rzedowski 43,302 (CAS); Querétaro, Mexico; H. Elytraria marginata Vahl; FJ868937, —; 19860332cv, cultivated at BR (Democratic Republic of Congo); S. Elytraria mexicana Fryxell & S.D. Koch; FJ868931, FJ868915; T.F. Daniel 5,284 (CAS); Colima, Mexico; H. Elytraria minor O.B. Dokosi; FJ868938, —; Faulkner 1,783A (BR); Tanzania; H. Elytraria nodosa E. Hossain; FJ868939, FJ868919; T.F. Daniel et al. 10,452 (CAS); Antsiranana, Madagascar; S. Elytraria planifolia Leonard; FJ868934, FJ868916; R.A. Howard et al. 341 (NY); Villa Clara Province, Cuba; H. Elytraria prolifera Leonard; FJ868935, FJ868917; Plantae Indiae Occidentalis 8,877 (NY); Ile La Gunave, Haiti; H. Nelsonia canescens (Lam.) Spreng.; FJ868932, —; T.F. Daniel et al. 5,452cv, cultivated at the San Francisco Conservatory of Flowers (Panama); S. Ophiorrhiziphyllon macrobotryum Kurz; —, FJ868908; J.F. Maxwell 91-213 (CAS); Mae Hong Song, Thailand; H. Staurogyne concinnula (Hance) O. Kuntze; FJ868922, FJ868909; Bartholomew & Boufford 6,215 (CAS); Taipei Hsien, Taiwan; H. Elytraria acaulis Lindau: tropical and southern Africa, Indian subcontinent

Appendix II

Species of *Elytraria* and their native distributions.

Elytraria bissei H. Dietr.: Cuba
Elytraria bromoides Oerst.: North America, northern Central America
Elytraria caroliniensis (Gmel.) Pers.: southeastern USA
Elytraria cubana Alain: Cuba
Elytraria filicaulis Borhidi & O. Muniz: Cuba
Elytraria imbricata (Vahl) Pers.: North America, Central America, South America
Elytraria ivorensis Dokosi: tropical western Africa
Elytraria klugii Leonard: Peru
Elytraria lyrata Vahl: tropical Africa
Elytraria macrophylla Leonard: Mexico
Elytraria madagascariensis (R. Ben.) E. Hossain: Madagascar
Elytraria marginata Vahl: tropical western and central Africa
Elytraria maritima J.K. Morton: tropical western Africa
Elytraria mexicana Fryxell & S.D. Koch: Mexico
Elytraria minor Dokosi: tropical eastern Africa
Elytraria nodosa E. Hossain: Madagascar
Elytraria planifolia Leonard: Cuba
Elytraria prolifera Leonard: Haiti
Elytraria shaferi (P. Wilson) Leonard: Cuba
Elytraria spathulifolia Borhidi & O. Muniz: Cuba
Elytraria tuberosa Leonard: Ecuador

Copyright © 2009 by the California Academy of Sciences
San Francisco, California, U.S.A.

PROCEEDINGS OF THE CALIFORNIA ACADEMY OF SCIENCES

Series 4, Volume 60, No. 6, pp. 69–72, 1 fig. May 7, 2009

Blakea attenboroughii (Melastomataceae: Blakeeae): A New Species from Ecuador

Darin S. Penneys[1] **and Lou Jost**[2]

[1]*Department of Botany, California Academy of Sciences, 55 Music Concourse Drive, Golden Gate Park,San Francisco, California 94118, U.S.A.; Email: dpenneys@calacademy.org;*
[2]*Baños, Tungurahua, Ecuador; Email: loujost@yahoo.com*

***Blakea attenboroughii*, a new Ecuadorian endemic is described, illustrated, and compared with several allied species, including *B. truncata, B. harlingii,* and *B. brasiliensis*. The new species is remarkable for its outer floral bracts that are large, foliaceous, distinctly keeled, decurrent, and basally adpressed to each other, and also for having lavender- to blue-colored anthers.**

Blakea (Melastomataceae: Blakeeae) is a Neotropical genus comprised of ca. 100 species of woody root climbers, shrubs, and trees that may be terrestrial, hemiepiphytic, or epiphytic (Almeda 2000). Found from Mexico to Bolivia, including several species in the Antilles, these berry-fruited plants are characterized by their solitary to fascicled, axillary flowers, that are subtended by two pairs of decussate bracts, and laterally compressed anthers (Penneys 2007). The species proposed here is currently known only from the type locality within the Reserva Ecológica Cerro Candelaria (Fundación EcoMinga), Tungurahua, Ecuador. This species is distinctive for having large, keeled, and foliaceous outer floral bracts that are basally decurrent and adpressed to each other, as well as for having lavender- to blue-colored anthers. This combination of characters is unique in the genus.

***Blakea attenboroughii* Penneys, sp. nov.**

TYPE.— ECUADOR. **Tungurahua**: Reserva Ecológica Cerro Candelaria (Fundación EcoMinga), Río Chinchin Grande, 1890 m, Nov. 2007 (bud, fl), *Lou Jost, Javier Robayo, A. Recalde, J. Recalde* 8545 (holotype: QCNE; isotypes: CAS, NY, QCA). Figure 1.

Frutex hemiepiphyticus. Ramuli primum quadrangulati demum teretes. Petioli 6–20 mm longi; lamina 6.0–12.5 × 2.8–5.0 cm, elliptica vel angosto-obovata, apice obtusa vel rotundata, caudato-acuminata, basi acuta vel angosto-obtusa, ad maturitatem coriacea et glabra, 5-nervata, nervis secundariis 0.5–1.1 mm inter se distantibus. Flores 6-meri in quoque nodo superiore 1-2, peduncularis 27–45 mm longis; bracteae exteriores 30–39 × 13–18 mm ellipticae ad basim paulo (ca. 2 mm) coalitae; bracteae interiores 11–16 × 8–12 mm lato-obovatae omnino liberae. Hypanthium (ad torum) 7.5–8.5 mm longus; calyces tubus 2.0–2.5 mm longus, lobis 0.1–0.2 mm longis. Petala 16–18 × 14–16 mm obovato-subrhombica. Antherae 7.7–8.1 × 3.0–3.2 mm, inter se lateraliter cohaerentes apice minute biporosae; connectivum ad basium dorsaliter dente 3.2–3.6 mm descendenti armatum. Ovarium 6-loculare.

Hemiepiphytic shrubs. Upper branchlets quadrate, becoming terete with age. Vegetative buds, young branchlets, young petioles, adaxial and abaxial leaf surfaces, and inner and outer floral bracts glabrous except very sparsely provided with sessile, globular-glandular and granulose hairs.

Mature leaves of a pair equal to somewhat unequal in size, isomorphic; petioles 6–20 mm long; blades planar, subcoriaceous, 6.0–12.5 × 2.8–5.0 cm, elliptic to narrowly obovate, apex obtuse to rounded and acuminate to caudate-acuminate, base acute to narrowly obtuse, shortly decurrent, margin entire, 5-nerved, striolate transverse secondary veins spaced 0.5–1.1 mm apart at widest portion of blade. Flowers erect, 1–2 in each leaf axil of uppermost branches; peduncles 27–45 mm long, elenticellate, quadrangular, distal wings formed by decurrent outer floral bracts. Outer floral bracts subcoriaceous, foliaceous, basally tinged red during anthesis, becoming reddish and showy in fruit, 30–39 × 13–18 mm, fused basally for ca. 2 mm, elliptic, apex acute to acuminate, spreading distally, base acute and winged-decurrent along peduncle, margin entire, multi-veined, the median vein prominently keeled, keel descending peduncle and jointed at point of ovary insertion; inner floral bracts subcoriaceous, pale green, 11–16 × 8–12 mm, free, broadly obovate, apex obtuse, spreading distally, margin entire, the median vein keeled. Hypanthium campanulate, obscurely 6-ribbed, 7.5–8.5 mm long to the torus, 7.1–7.3 mm wide, glabrous; inner hypanthium 2.4 mm high, glabrous, ridged. Calyx tube 2.2–2.4 mm long; calyx lobes 0.1–0.2 × 5.7–5.9 mm, glabrous on both surfaces, very broadly rounded, obscure, margin entire, external calyx teeth elongate, obscure, callose thickenings descending along hypanthium ribs. Petals 6, glabrous, 16–18 × 14–16 mm, widely obovate to subrhombic, white, entire, apex obtuse, shortly acuminate. Stamens 12, isomorphic; filaments adaxially keeled, laterally flanged, 8.4–8.6 mm long, cream, glabrous, declined to one side of the flower opposing the style; anthers laterally coherent, compressed, 7.7–8.1 × 3.0–3.2 mm, mostly lavender, dorsally blue on distal half to just below apex, connective appendage white; apical pores two, circular, 0.10 × 0.10 mm; anther sacs completely separated, thecae surfaces smooth; connective obscurely rugose, prolonged dorso-basally into a thick, triangular tooth 3.2–3.6 mm long, basally sulcate. Ovary inferior, 6-celled, glabrous, locules 3.1 × 5.4 mm, apex conic, 2 mm high, placentation intruded axile. Style straight, apically tapering, glabrous, 14–16 mm long; stigma truncate, 0.15 × 0.4 mm. Mature berry and seeds not seen.

Distribution and phenology.— Known only from the type locality, *Blakea attenboroughii* was found in the recently designated Reserva Ecológica Cerro Candelaria (Fundación EcoMinga), Tungurahua, Ecuador, at 1890 meters. The reserve lies on the eastern slopes of the Andes, between the Parque Nacional Los Llanganates and Parque Nacional Sangay. The type was collected in bud and flower in November, and a different plant (not collected) was observed fruiting in February.

Blakea attenboroughii is notable for its outer floral bracts that are large, foliaceous, basally adpressed, prominently keeled, and decurrent on the peduncles. In combination with its lavender- and blue-colored anthers, this species could be confused with the Colombian endemic, *B. truncata* Gleason (including the synonymous *B. mitrata* Uribe). Though these two species share a number of similar morphological characters, they can be readily distinguished. *Blakea attenboroughii* has petioles 6–20 mm long (vs. 2–7 mm in *B. truncata*); leaves with basal nerves that descend the petioles (vs. leaves plinerved); outer floral bracts prominently decurrent on the peduncles (vs. outer floral bracts not decurrent), connate basally for only ca. 2 mm (vs. connate ca. 9 mm); hypanthium 7.5–8.5 mm long to the torus × 7.1–7.3 mm diameter (vs. 10–13 × 15 mm); petals 16–18 × 14–16 mm (vs. 22–30 × 12 mm), widely obovate to subrhombic (vs. narrowly ovate to oblong-lanceolate), and with the apex obtuse and shortly acuminate (vs. acute to long-acuminate); filaments 8.4–8.6 mm long (vs. 10–11 mm long); anther connective appendage prolonged dorso-basally into a thick, triangular tooth 3.2–3.6 mm long (vs. a narrower, ascending spur, 4.5–5.5 mm long); ovary cone 2 mm high (vs. 5 mm); style straight (vs. curved); and stigma truncate (vs. punctiform).

Blakea attenboroughii is also quite similar to *B. harlingii* Wurdack, but the latter species lacks decurrent outer floral bracts, and has well-developed calyx lobes, ciliate petals, and anthers that are about 3 mm shorter. For its foliaceous outer floral bracts, *Blakea attenboroughii* bears some

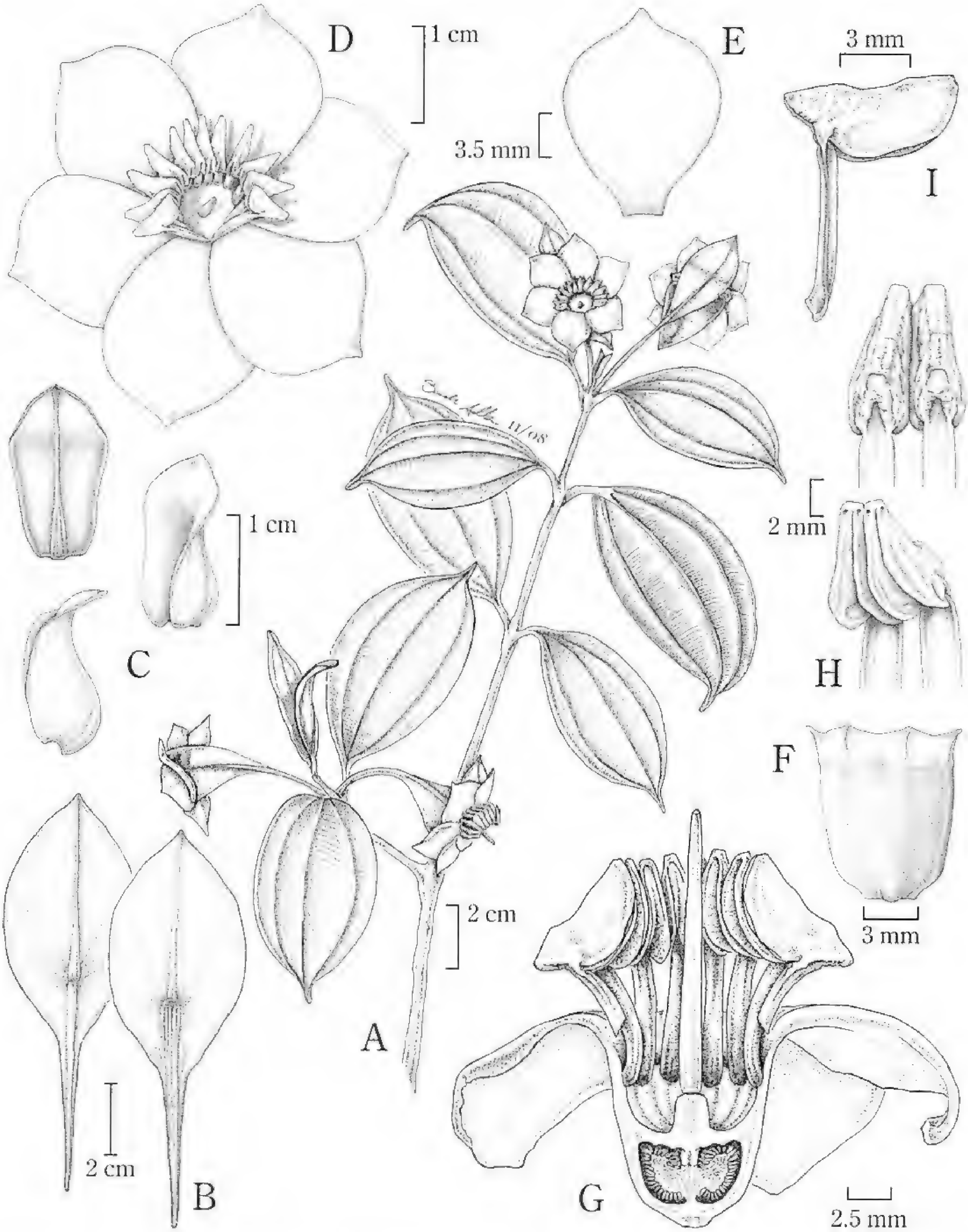


FIGURE 1. *Blakea attenboroughii* Penneys. A. Habit. B. Outer floral bracts, abaxial surface (left), adaxial surface (right). C. Inner floral bracts, abaxial surface (above), 3/4 view (right), lateral view (below). D. Flower. E. Petal (abaxial). F. Hypanthium and calyx. G. Flower, longitudinal section. H. Stamens, dorsal view (above), ventral view (below). I. Stamen, lateral view. (Reproductive structures drawn from spirit-preserved material of type specimen, *Jost, et al. 8545*.)

resemblance to *B. brasiliensis* Cogniaux, which itself is very closely allied to *B. standleyana* Macbride. The latter two species, however, have furfuraceous pubescence, lavender petals, and yellow anthers. They also occur at lower elevations in the western Amazon and eastern slopes of the Andes, with *B. standleyana* growing up to 1100 meters. The Central American *Topobea mcphersonii* Almeda has outer floral bracts remarkably similar to those of *B. attenboroughii*, but otherwise the two species diverge greatly, particulary in that the anthers of *T. mcphersonii* are only 3–5 × 1 mm, yellow, and linear-oblong.

ETYMOLOGY

This species is named in honor of the great natural historian, Sir David Attenborough, whose fundraising efforts permitted the land where it was discovered to be purchased.

ACKNOWLEDGMENTS

We thank Sarah Adler for preparing the line drawings, and the curators and staff of the California Academy of Sciences herbarium for logistical support.

LITERATURE CITED

ALMEDA, F. 2000. A synopsis of the genus *Blakea* (Melastomataceae) in Mexico and Central America. *Novon* 10:299–319.

PENNEYS, D.S. 2007. *Phylogeny and Character Evolution in the Blakeeae (Melastomataceae): Neotropical Hemiepiphytes with Mite and Ant Domatia*. Ph.D. dissertation, University of Florida, Gainesville, Florida, USA. 176pp.

Copyright © 2009 by the California Academy of Sciences
San Francisco, California, U.S.A.

PROCEEDINGS OF THE CALIFORNIA ACADEMY OF SCIENCES

Series 4, Volume 60, No. 7, pp. 73–84, 16 figs., 1 table May 7, 2009

A New and Endemic Species of *Nebria* Latreille (Insecta: Coleoptera: Carabidae: Nebriini), Threatened by Climate Change in the Trinity Alps of Northern California

David H. Kavanaugh[1] **and Sean D. Schoville**[2]

[1] Department of Entomology, California Academy of Sciences, 55 Music Concourse Drive, San Francisco, CA 94118, USA; Email: dkavanaugh@calacademy.org; [2] Department of Environmental Science, Policy and Management University of California, Berkeley, CA 94720, USA; Email: schoville@nature.berkeley.edu

***Nebria praedicta*, new species, is described from the highest elevations of the Trinity Alps of northern California (type locality = U.S.A., California, Trinity County, north by northwest slope of Thompson Peak in upper Grizzly Lake Basin). Based on collection records, this species is endemic to the region and now probably restricted to northern slopes of this single high massif, where it has been found only at and below the toe of a catastrophically receding glacier. This species is most closely related to *Nebria vandykei* of the Cascade Range in Washington and Oregon, based on characters of external and male and female genitalic form and structure and on preliminary DNA sequence comparisons. Its existence was predicted from the Cascade-Trinity Alps vicariant distribution of the species pair, *Nebria paradisi* Van Dyke and *Nebria turmaduodecima* Kavanaugh, which occupy the same habitats in the respective regions, and the widespread co-occurrence of *N. paradisi* with *N. vandykei*. Characteristics are provided for distinguishing *N. praedicta* adults from those of closely related species; and the imminent threat to the survival of the species from climatic change is discussed.**

KEYWORDS: Coleoptera, Carabidae, Nebriini, *Nebria*, California, Trinity Alps, catastrophic glacial recession, climate change

In 1981, *Nebria turmaduodecima* Kavanaugh was described from upper Caribou Basin in the Trinity Alps of northwestern California, where adults were found at the margins of a persistent snowfield at an elevation of 2380 m (Kavanaugh 1981). This species, endemic to the Trinity Alps, is most closely related to *Nebria paradisi* Darlington (1930, 1931) (Kavanaugh 1985), which is restricted to the Cascade Range, from northern Washington south to Mt. Hood in northern Oregon. Members of *N. paradisi* live in the same habitat as *N. turmaduodecima* members; and wherever they occur in that habitat, they are found with members of another species, *Nebria vandykei* Bänninger (1928). Because of this widespread habitat association of *N. paradisi* with *N. vandykei*, the senior author (DHK) expected that, eventually, either *N. vandykei* itself or a closely related species would be found in the Trinity Alps associated with *N. turmaduodecima*. The most likely place to find this predicted species was high on the northern slopes of Thompson Peak, the highest peak in the Trinity Alps, at or near the glaciers and persistent snowfields on that slope. When the junior author (SDS) visited Grizzly Lake Basin, on the northern slope of Thompson Peak, on 13 September 2008, he looked for and found very large, black *Nebria* adults among the smaller, faintly metallic green adults of *N. turmaduodecima*.

Our subsequent study of external and genitalia morphology and preliminary DNA sequence data for these specimens has convinced us that they indeed represent a new and distinct species. The purpose of this paper is to describe this new species and distinguish its members from those of the two *Nebria vandykei* taxa, which are currently ranked as subspecies but may, in fact, represent distinct species—namely, *Nebria vandykei vandykei* Bänninger, from the Olympic Mountains and the Cascade Range of Washington, and *Nebria vandykei wyeast* Kavanaugh (1979), from volcanoes of the Cascade Range in northern to central Oregon. We also discuss our concern for the future survival of this species in the face of the current climatic warming trend.

MATERIALS AND METHODS

This report is based on study of the 23 specimens from the Trinity Alps, described here as representing a new species, and additional specimens representing all previously described Nearctic *Nebria* species. All but two of the specimens in the type series were collected directly into 95% ethanol to preserve them suitably for DNA sequencing and analysis. Institutional codons cited in the text:

CAS — California Academy of Sciences, San Francisco, California, USA
EMEC — Essig Museum of Entomology, University of California, Berkeley, California, USA

Methods used in the present study, including dissection techniques and criteria for ranking taxa as distinct species, were as described in Kavanaugh (1979). The only measurement used is standardized body length (SBL), which equals the sum of the lengths of the head (measured from apex of clypeus to a point on midline at level of posterior margin of compound eye), pronotum (measured from apical margin to basal margin along midline), and elytra (measured along midline from apex of scutellum to apex of the longer elytron). Following dissection, preparations of female genitalic structures were stained with Chlorosol Black E and digitally photographed using an Automontage imaging system by Syncroscopy with a Leica M420 dissecting microscope. Digital photographs of dorsal habitus, pronotum, and male and female genitalia were also taken with the automontage system.

DESCRIPTION

Nebria praedicta Kavanaugh and Schoville, sp. nov.

Figures 1-2, 5, 8-9, 11, 13, 16.

TYPES.— Holotype, a pinned male, deposited in CAS, labeled: "CASENT1039942"/ "U.S.A., California, Trinity County, Trinity Alps, NNW slope of Thompson Peak below glacier in upper Grizzly Lake Basin, N41.00458°/W123.04799° to N41.00301°/ W123.04807°, 2411–2470 m, 13 September 2008, S. D. Schoville collector"/ "IMAGE" [pale blue label]/ "HOLOTYPE *Nebria praedicta* Kavanaugh & Schoville n. sp. designated. by D.H. Kavanaugh & S. D. Schoville 2009" [red label]/"California Academy of Sciences Type No. 18447". A total of 22 paratypes (10 males and 12 females) are deposited in CAS and EMEC, each with same locality label as holotype, but labeled: "PARATYPE *Nebria praedicta* Kavanaugh & Schoville n. sp. designated. by D.H. Kavanaugh & S.D. Schoville 2009" [yellow label].

TYPE LOCALITY.— North by northwest slope of Thompson Peak in upper Grizzly Lake Basin, 41.00458°N,123.04799°W to 41.00301°N, 123.04807°W, Trinity County, California, U.S.A.

ETYMOLOGY.— The specific epithet, *praedicta*, is the perfect participle of the Latin verb, *praedico* (meaning. to predict), used as an adjective in the nominative singular, in reference to the predicted occurrence of a member of the *vandykei* species-subgroup in the Trinity Alps.

Diagnosis.— Adults of this species can be distinguished from those of all other Nearctic *Nebria* species by the following combination of character states: both males and females with SBL greater than 12.0 mm; body (Fig. 1) and appendages black or piceous, vertex with pair of paramedial pale spots; dorsal body surface without metallic reflection; elytral microsculpture comprised of moderately deeply impressed isodiametric meshes; antennal scape (Fig. 2) symmetrical or slightly swollen sub-basally, straight, medium-length; pronotum (Fig. 5) with basal sinuation of lateral margins distinct, moderately deep and long, midlateral and basolateral setae present; elytral silhouette distinctly and symmetrically ovoid, elytra markedly flattened (especially at lateral declivity), intervals only moderately convex, striae moderately punctate; female genitalia with lateral lobe of basal apodeme of sternite VIII (Fig. 9) extremely short, bursa copulatrix (Fig. 11) without sclerites, spermathecal duct straight or slightly arcuate and deflected moderately right of midline proximally and irregularly convoluted distally; specimen from Trinity Alps of northwestern California.

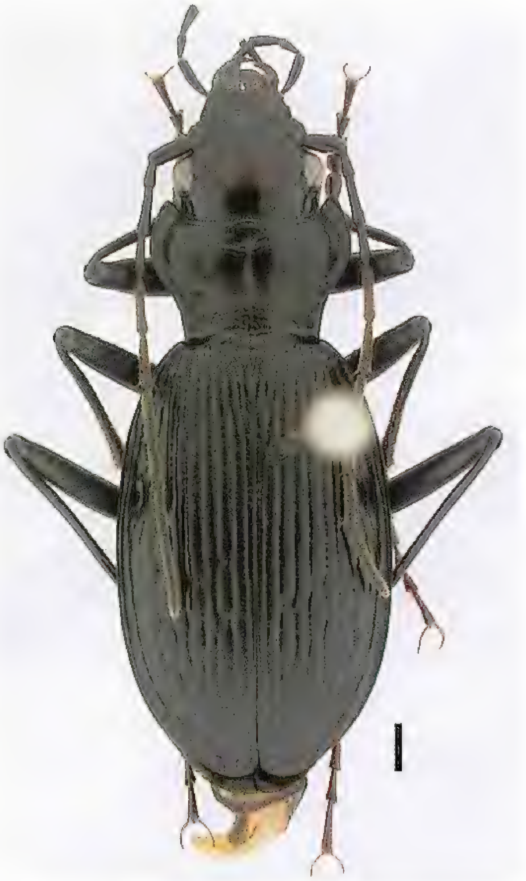
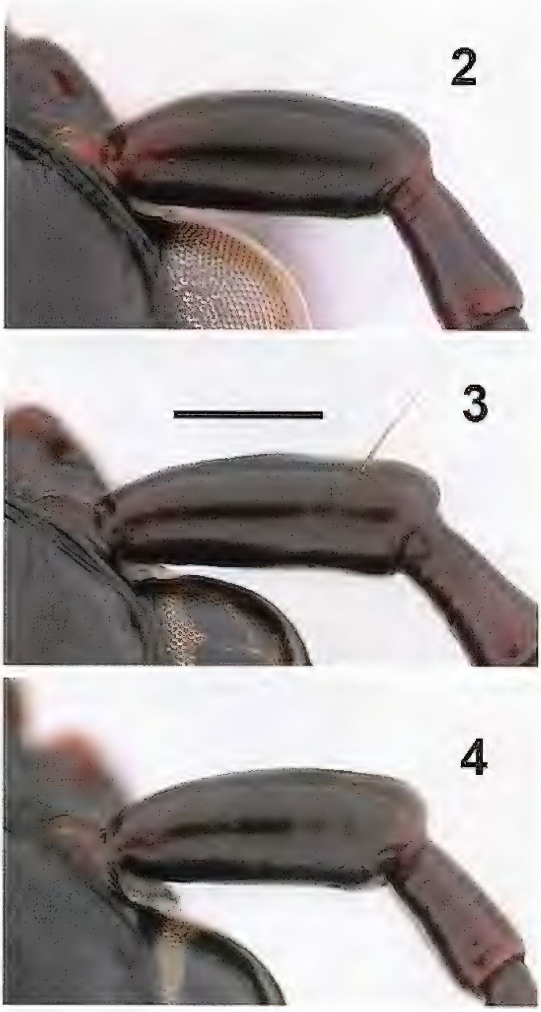
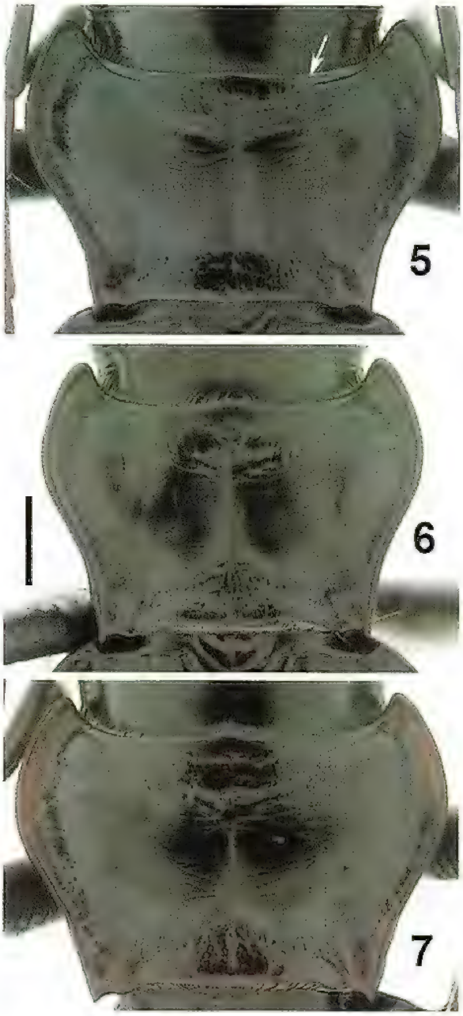


Figure 1. Digital image of holotype, *Nebria praedicta* new species; habitus, dorsal aspect; scale line = 1.0 mm.

Comparisons. Members of this species are most similar, in external and genitalia morphology, to those of both subspecies of *Nebria vandykei* Bänninger, with which they share large size, dark, non-metallic body and appendage color, markedly ovoid elytra, distinctly catenate elytral intervals 3, 5, and 7, virtually identical male genitalia, and female genitalia without sclerites on the bursa copulatrix. *Nebria praedicta* adults differ with those of both *N. vandykei* subspecies in the following traits: antennae very long (with the scape extended laterally at 90° to the longitudinal body axis, the distal two antennomeres extend posteriorly beyond elytral mid-length) (at most only the distal-most [eleventh] antennomere extends beyond elytral mid-length in members of either *N. vandykei* subspecies), the antennal scape nearly straight, medium-length, and slightly swollen sub-basally or symmetrical (Fig. 2) (slightly arcuate and narrowed basally in both *N. vandykei* subspecies, medium-length in *N. v. vandykei* (Fig. 3) and more elongate in *N. v. wyeast* (Fig. 4)); pronotum (Fig. 5) with basal sinuation of the lateral margin long and moderately deep (shallower and shorter in both *N. vandykei* subspecies (Figs. 6 and 7)), anterior margination more nearly complete medially and distinctly divided into two parallel beads by a finely impressed secondary transverse sulcus paramedially (Fig. 5) (anterior margination restricted to lateral thirds and without or with only a faint median sulcus dividing the margination into parallel beads (Fig. 6 or 7) in *N. vandykei* subspecies); elytral silhouette (Fig. 1) symmetrically ovoid (very slightly narrower basally than apically in the *N. vandykei* subspecies), elytra markedly flattened, especially at the lateral declivity (most noticeably just anterior to the subhumeral sinuation) (slightly more convex



Figures 2-4. Digital images of right antennal scape, dorsal aspect; scale line = 0.5 mm. Fig. 2. *Nebria praedicta* new species. Fig. 3. *Nebria vandykei vandykei* Bänninger. Fig. 4. *Nebria vandykei wyeast* Kavanaugh.



Figures 5–7. Digital images of pronotum, dorsal aspect; scale line = 1.0 mm; white arrow = secondary transverse sulcus within anterior margination. Fig. 5. *Nebria praedicta* new species. Fig. 6. *Nebria vandykei vandykei* Bänninger. Fig. 7. *Nebria vandykei wyeast* Kavanaugh.

overall and especially at the lateral declivity in both *N. vandykei* subspecies), elytral striae moderately punctate (only slightly punctate in *N. vandykei* subspecies), elytral intervals only moderately convex (markedly in *N. vandykei* subspecies); lateral lobe of the basal apodeme of abdominal sternite VIII in females (Fig. 9) extremely short (longer and more similar in length to the medial lobe in *N. vandykei* subspecies (Fig. 10)); spermathecal duct of females (Fig. 11) with a longer, straighter, and more distinctly deflected right proximal section (proximal section shorter, more arcuate than straight, and less distinctly deflected right in *N. vandykei* subspecies (Fig. 12)). Additionally, the following trends separate many or most adults of *N. praedicta* from those of *N. vandykei* subspecies: the smallest males and females of *N. praedicta* are larger (13.0 mm and 13.4 mm, respectively) than the smallest males and females of the *N. vandykei* subspecies (12.0 mm and 12.6 mm, respectively); *N. praedicta* adults have fewer catenations on elytral intervals 3 (two to six catenations), 5 (zero to six catenations), and 9 (11 to 16 catenations in the umbilicate series) than adults of *N. vandykei* subspecies (with four to seven, three to seven, and 14 to 19 catenations on intervals 3, 5, and 9, respectively). In addition, *N. praedicta* is a species apparently restricted to the highest elevations of the Trinity Alps in northwestern California, whereas the *N. vandykei* subspecies occur only in the Cascade Range of Oregon (*N. v. wyeast*) and the Cascade Range and Olympic Mountains of Washington (*N. v. vandykei*) (Fig. 13).

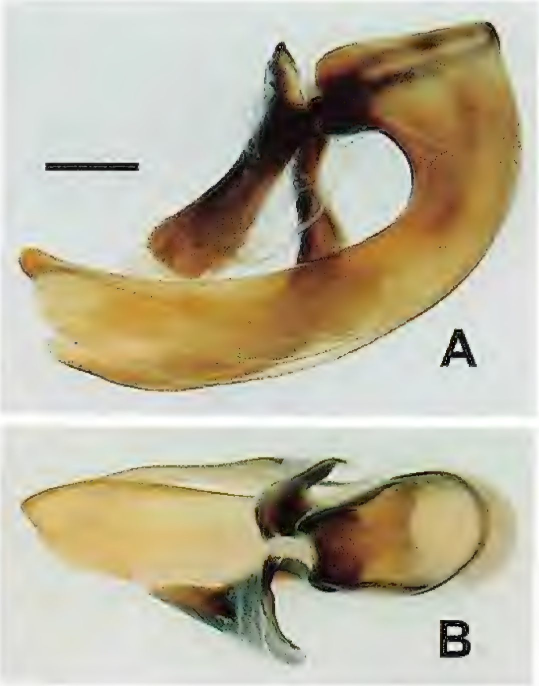
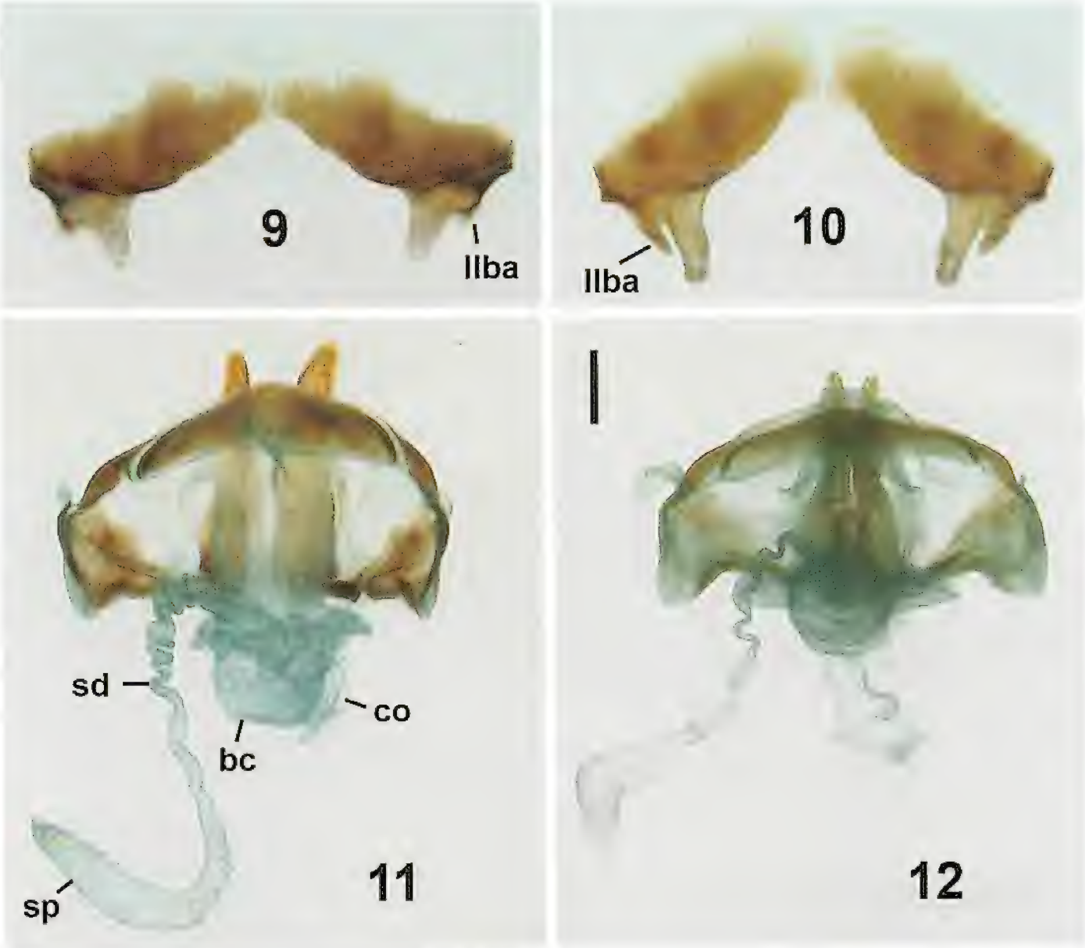


FIGURE 8. Digital image of male median lobe of aedeagus, *Nebria praedicta* new species; A = left lateral aspect; B = ventral aspect; scale line = 0.5 mm.

DESCRIPTION.— Body size large for *Nebria*, SBL males 13.0–14.2 mm, SBL females 13.4–14.8 mm; head black or piceous, with pair of paramedial pale spots present on vertex; pronotum, elytra, and legs black or piceous; dorsum and venter without metallic reflection; frons and vertex smooth or nearly so; microsculpture with sculpticells regularly isodiametric, flat, faintly impressed on frons, moderately impressed on pronotum and elytra.

Head.— Size and width relative to pronotum greater than average for genus, slightly greater in females than males; genae and occiput moderately inflated, slightly more inflated in females than males. Eyes slightly reduced in diameter, moderately convex. Antennae moderately elongate; scape (Fig. 2) medium-length, slightly arcuate, slightly swollen anterobasally, with one anterodorsal seta subapically; pedicel with one ventral seta subapically; flagellar antennomeres moderately elongate, slender. Labrum with apical margin slightly to moderately bisinuate. Clypeus with apical margin truncate or slightly concave and slightly emarginate. Mentum with pair of M2 setae (setal nomenclature as in Kavanaugh 1979) long and slightly to moderately far removed from basal margin. Submentum with three or four pairs of lateral setae (five setae unilaterally in a few individuals) and one pair of medial setae (absent or with two setae unilaterally in a few individuals).

Pronotum.— Size and width relative to elytra average for genus; shape (Fig. 5) moderately cordate and slightly convex, basal margin distinctly narrower than apical margin; lateral margins moderately arcuate, with basal sinuation long and moderately deep; lateral explanation present throughout pronotal length, moderately broad at middle and basally and slightly broader apically; basal margin markedly bisinuate; apical angles moderately long, slightly narrow, and moderately rounded; basal angles slightly obtuse, projected posteriorly, distinctly dentate apicoposteriorly; lateral margination ("lateral bead") present throughout, widened apically, slightly narrowed and more faintly impressed at middle; anterior margination complete or incomplete only near midline, moderately to markedly impressed, divided into two thin beads paramedially by a finer secondary transverse sulcus, anterior transverse impression narrow and moderately deep; posterior transverse impression narrow and deep; basal foveae deep, moderately broad, and moderately divergent basally; midlateral and basolateral setae present.



FIGURES 9–12. Digital images of female genitalia and reproductive system. Figs. 9–10. Sternite VIII, ventral aspect; llba = lateral lobe of basal apodeme; scale line = 0.5 mm. Fig. 9. *Nebria praedicta* new species. Fig. 10. *Nebria vandykei wyeast* Kavanaugh. Figs. 11–12. Female reproductive system, dorsal aspect; bc = bursa copulatrix; co = common oviduct; sd = spermathecal duct; sp = spermathecal reservoir; scale line = 0.5 mm. Fig. 11. *Nebria praedicta* new species. Fig. 12. *Nebria vandykei vandykei* Bänninger.

Thoracic venter.— Prosternal intercoxal process moderately lanceolate, smooth with margination intercoxal process present laterally only, from base to slightly posterior to coxa. Mesosternum smooth. Mesepisternum faintly punctulate. Metasternum smooth throughout, moderately shortened; margination of anterior intercoxal process absent or only vaguely impressed medially. Metepisternum smooth.

Elytra.— Slightly shorter in relation to length of forebody than average for genus, slightly longer in most females than in males, moderately wide and markedly flattened; elytral silhouette (Fig. 1) symmetrically ovoid; basal marginations slightly shortened, straight or slightly concave; humeri markedly rounded, humeral carina distinct and sharp but not projected, humeral teeth absent; subhumeral sinuation shallow; elytral apices moderately divergent from midline, apices obliquely angulate medially and rounded apically; elytral striae markedly deep, moderately punctate; intervals slightly to moderately convex and smooth, intervals 3, 5 , 7, and 9 markedly catenate, interval 3 with two to six setiferous catenations (only three or four in most individuals), interval 5 with zero to six setiferous catenations (one to three in most individuals), interval 7 with three to seven setiferous catenations (three to five in most individuals), and interval 9 with 11 to 16 setiferous catenations; basal setiferous pore absent.

Hind wings.— Short and narrow, stigma reduced.

Legs.— Markedly long; hind coxae with two or three setae basally (four unilaterally in a few individuals) and one seta apically. Hind trochanter kidney-shaped, medium length, truncate or broadly rounded apically. Middle tibiae with dorsal sulcus present in middle third, with moderately dense setal brush present dorsosubapically. Tarsi without pubescence dorsally; protarsi of males with basal three tarsomeres broadened and with pads of adhesive setae ventrally; hind tarsi with ventroapical margin of tarsomere 4 slightly to moderately lobed laterally.

Abdomen.— Sternite II (first visible sternite) smooth; sternite III without setae; sternites IV to VI with three to seven pairs of posterior paramedial setae and two to eight pairs of paralateral setae (present on sternite IV in all specimens examined, absent from sternites V and VI in a few specimens examined); sternum VII of males with two posterior paramedial ("anal") setae (some individuals with one or three setae unilaterally), of females with two or three pairs of setae (some individuals with four setae unilaterally).

Male genitalia.— Median lobe of aedeagus (Fig. 8) with mid-shaft slightly thickened, moderately narrowed basally, with its axis bent to a slightly acute (< 90 degrees) angle (in lateral aspect), moderately compressed (in cross-section), right face of mid-shaft unmodified; preapical-shaft markedly broad and moderately tapered apically, ventral margin slightly deflected ventrally (in lateral aspect), broad, moderately tapered, and moderately deflected right (in dorsal aspect); apical orifice markedly deflected right; apical lamella connected slightly right of center on preapical shaft, moderately deflected right, and with bluntly pointed apex (in ventral aspect), plane of lamellar face markedly twisted left (in apical aspect), lamellar apex moderate in length and broadly blunt, with axis slight-

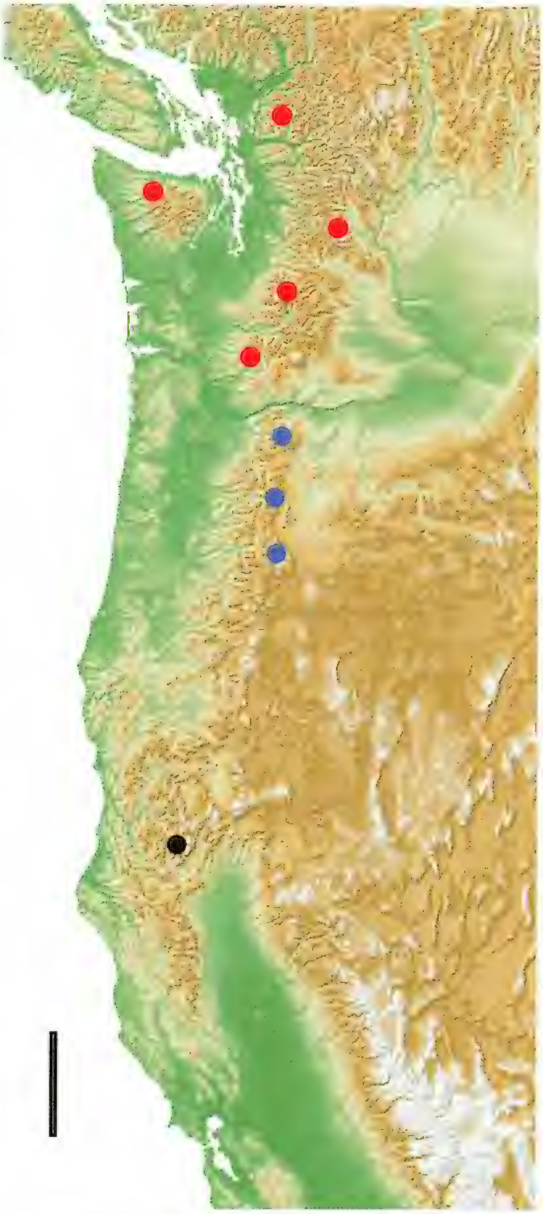


FIGURE 13. Map of the west coast of North America, from southern British Columbia to northern California (California Albers projection), showing the known geographical distributions of *Nebria praedicta* new species (black dots), *Nebria vandykei vandykei* Bänninger (red dots), and *Nebria vandykei wyeast* Kavanaugh (blue dots); scale lines = 100 km.

ly deflected ventrally (in lateral aspect). Parameres asymmetrical, with right much longer than left; left paramere short, broad, slightly narrowed basally; right paramere slender, moderately long, with right medial parametric sclerite present, distinct.

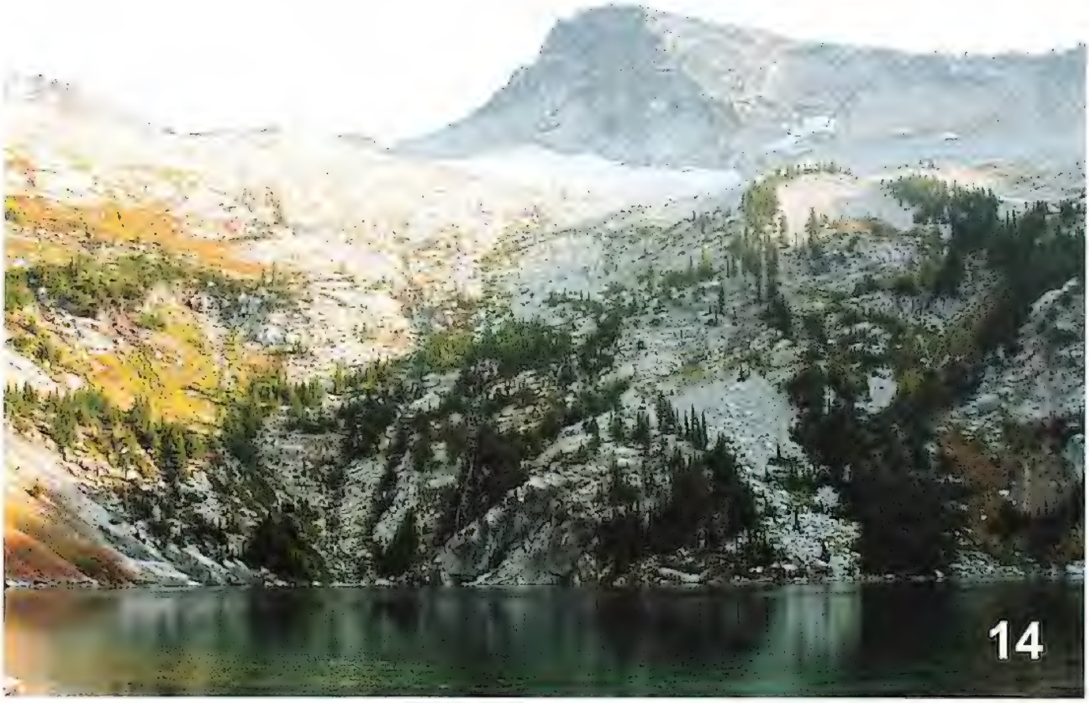
Female genitalia.— Hemisternites of segment VIII (Fig. 9) with a fringe of short and medium-length setae medially on the apical margin, otherwise glabrous; basal apodemes wide, markedly emarginate, with lateral lobes much shorter than medial lobes. Ovipositor with gonocoxite I and gonocoxite II fused medially, moderately broadly separate laterally; gonocoxite I not or only faintly sclerotized ventrally apicomedially to basolaterally, fully sclerotized medially, with a diagonal (basolateral to apicomedial) row of four to six medium-length setiform setae ventrally; gonocoxite II slightly shortened and of moderate width, bluntly rounded apically and moderately bent ventrolaterally (in lateral aspect), with three or four short or medium-length setiform mediodorsal setae in a longitudinal row; both gonocoxites with moderately dense vestiture on medial surface. Bursa copulatrix (Fig. 11) with longitudinal axis moderately sigmoid (in lateral aspect); spermathecal chamber medium-length, broadly cordate and symmetrical (in dorsal aspect), without accessory lobes or sclerites; spermathecal reservoir arcuate, simple, medium-length; spermathecal duct medium-length, moderately thick, straight, and moderately deflected right proximally, irregularly convoluted distally, inserted at posterior end of spermathecal chamber at base of vertical (posterior) face of chamber in midline.

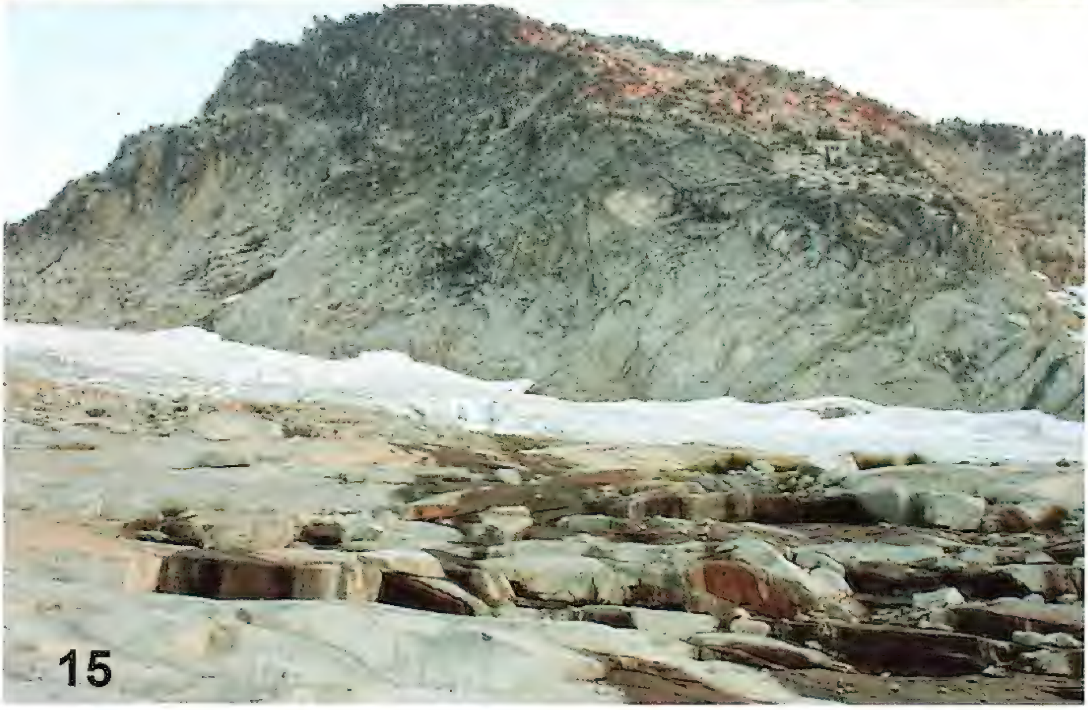
SEXUAL DIMORPHISM.— The smallest *N. praedicta* males are slightly smaller than the smallest females and the largest females are slightly larger than the largest males, but the sexes overlap broadly in overall body length. The basal three tarsomeres of the male protarsi are broad and have dense pads of adhesive setae ventrally. These tarsomeres are slender and without such setal pads in females. In most males, abdominal sternite VII has two pair of posterior paramedial setae (one or three setae unilaterally in a few individuals); in females, either two or three pairs of posterior paramedial setae are present (four setae unilaterally in a few individuals).

GEOGRAPHICAL DISTRIBUTION.— This species is known only from the type locality in upper Grizzly Lake Basin, at 2410 to 2470 m elevation, on the north by northwest slope of Thompson Peak in the Trinity Alps of the Klamath Mountains System, Trinity County, California (Fig. 13). The north-facing slopes of Thompson Peak are probably the only sites in the Trinity Alps where this species occurs, and it is most likely endemic to this area.

HABITAT DISTRIBUTION.— The specimens that form the type series of *N. praedicta* were collected in an area of smooth, sloped, unvegetated granitic bedrock, with abundant loose rockfall scattered on the bedrock surface, below the lower edge of the glacier in the head of Grizzly Lake Basin (Fig. 14). In daytime, beetles were found hiding under stones around seeps and glacial meltwater flowing over the bedrock (Fig. 15). Beetles were found in the same habitat at night, actively foraging along the water edges (Fig. 16). One individual was observed emerging from underneath the glacier's lower edge, and another was seen walking in the water against the current up a 15^0 slope, the latter behavior previously observed among *Nebria* species only for *Nebria ingens* Horn (Kavanaugh 1971). Numerous specimens of *Nebria turmaduodecima* were also found, both day and night, in the same habitat, together with *N. praedicta* specimens. Viewed from the bedrock periphery of the glacier, no *Nebria* were observed on the glacial ice at night, although numerous staphylinid beetles were seen foraging on horizontal and vertical surfaces along the glacial margins. A visual survey on the glacier itself was not conducted because of dangerous ice conditions (see Discussion below).

PHYLOGENETIC RELATIONSHIPS.— Based on characters of external morphology and form and structure of both male and female genitalia, *N. praedicta* is most closely related to *Nebria vandykei* Bänninger, members of which share the following synapomorphies: large body size, dark, non-





FIGURES 14–15. Fig. 14. View of the NNE face of Thompson Peak, taken from the N shore of Grizzly Lake, type locality for *Nebria praedicta*, sp. nov. The small, remnant glacier is clearly visible at the base of the face at the upper edge of the basin. Fig. 15. View of lower edge of the glacier in upper Grizzly Lake Basin, 2490 m elevation, showing granitic bedrock, loose rockfall cover, and meltwater seep areas where *Nebria praedicta* adults are found.

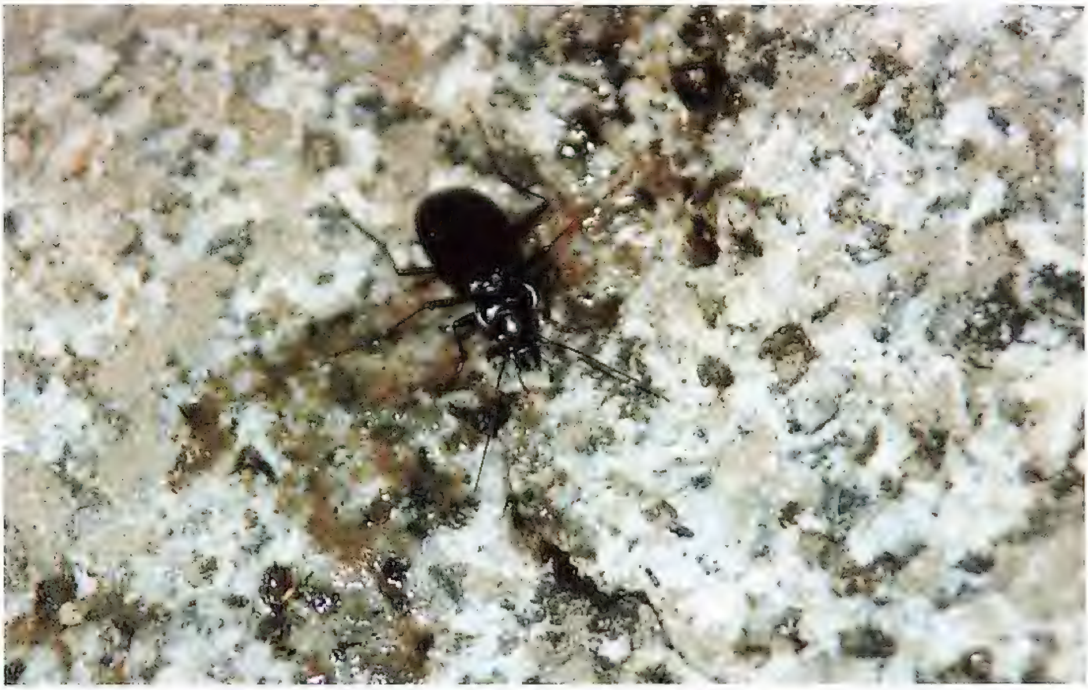


FIGURE 16. Photograph of a *Nebria praedicta* adult male actively foraging at night over granitic bedrock along a small meltwater trickle.

metallic body and appendage color, markedly ovoid elytra, and distinctly catenate elytral intervals 3, 5, and 7.

Results from a preliminary analysis of DNA sequence data also support a close relationship between *N. praedicta* and *N. vandykei*, with *N. praedicta* recognized as a distinct species. We amplified approximately 1690 base pairs of mitochondrial DNA spanning part of cytochrome oxidase subunit I, all of tRNA Leucine, and part of cytochrome oxidase subunit II (positions 1709–3400 in *Drosophila yakuba*). A combination of universal primers (C1-J1709 with C1-N2353 & C1-J2183 with C2-J3400) was used to amplify two overlapping regions under standard PCR conditions, and an additional internal primer (C1-N2776) was used in DNA sequencing (Simon et al. 1994 and 2006). We calculated the number of uncorrected pairwise differences between multiple individual sequences of *N. v. vandykei* (2 individuals from Mt. Rainier), *N. v. wyeast* (5 individuals from Middle Sister Peak), and *N. praedicta* (15 individuals from the type locality). The average pairwise differences between these taxa are as shown in Table 1. The program MRBAYES v3.1.2 (Ronquist, Huelsenbeck, 2003) was used to estimate a Bayesian phylogeny to assess the monophyly of each species. Samples of *Nebria ingens*, as well as *N. sierrae* and *N. meanyi lamarckensis* from the Sierra Nevada Mountains were used as outgroup taxa. All specimens included in the analysis were shown to be monophyletic genetically for their respective populations.

GEOGRAPHICAL RELATIONS WITH MOST CLOSELY RELATED SPECIES.— The known geographical range of *N. praedicta* is allopatric with respect to those of *N. v. vandykei* and *N. v. wyeast* (Fig. 13). *Nebria v. vandykei* is confined to the Olympic Mountains of westcentral Washington and the Cascade Range from Mount Baker in the north to Mount St. Helens in the south, at elevations between 1190 and 2040 m. The known range of *N. v. wyeast* is confined to the Cascade Range in Oregon, from Mount Hood south to the Three Sisters, at elevations from 1680 to 2190 m. The closest known localities for *N. praedicta* and *N. vandykei* are separated by 356 kilometers linear dis-

TABLE 1. Percent uncorrected pairwise difference of 1639 base pairs of cytochrome oxidase subunit I, tRNA-Leucine, and cytochrome oxidase subunit II.

	N. v. vandykei	*N. v. wyeast*	*N. praedicta*
N. v. vandykei	——	0.24%	1.46%
N. v. wyeast	0.24%	——	1.37%
N. praedicta	1.46%	1.37%	——

tance and an intervening area of relatively low elevation (including areas below 1000 m elevation) and unsuitable habitat.

The only other areas in northwestern or northcentral California with similar elevation and habitat to that found high in the Trinity Alps are the north slope of Mount Eddy (on the border of Trinity and Siskiyou Counties) and Mount Shasta (Siskiyou County), 62 and 83 km NE of Thompson Peak, respectively. Although slightly higher than Thompson Peak, Mount Eddy is more inland, hotter and drier, and with very porous substrate; so it is likely too warm and dry for survival of *N. praedicta*. Mount Shasta, like Mount Eddy, is more inland and has very porous volcanic substrate; but it is much taller and bears several glaciers and many large perennial snowfields, particularly high on its northern slope, which may afford suitable habitat for this species (see above). Collecting on the southern and eastern slopes (to 3500 m) and in the summit areas of Mount Shasta by one of us (DHK) and numerous amateur collectors over many years has failed to discover specimens of this species or of *N. vandykei*, which might also (but less likely) occur there.

DISCUSSION.— We are delighted to have discovered this elegant new species and pleased to be able to describe it. However, we have serious concerns about the prospects for its continued survival. As reported by Stone (2008), the large snowfield found at the type locality for *N. turmaduodecima* in upper Caribou Basin (at 2400 meters) on 12 August 1980 (when the type series was collected) had disappeared completely by the same date in 2007; and no individuals of that species were found at that site on the latter date. We are pleased to record that this species is still extant in upper Grizzly Lake Basin at elevations above 2400 meters. At the time that the type series of *N. praedicta* was collected, on 13 September 2008, glacial ice was calving audibly and visibly in large chunks (pieces two to three meters across) along the lower edge of the glacier in upper Grizzly Basin, with a seeping outflow from the melting ice along the entire edge. Based on the extent of collapsed ice within a four-meter margin of the glacier's edge, it was clear that the glacier was retreating rapidly. With no more than an estimated 30 meters of ice remaining between the glacier's lower and upper edges, it's difficult to imagine this ice mass, the largest in the Trinity Alps, persisting under current warming trends.

Without doubt, *Nebria praedicta* depends on persistent snow and ice to provide a microclimate cool enough through the warm months of the year for its members to survive. The glacier in upper Grizzly Basin and the even smaller glaciers or snowfields in adjacent cirques on the north side of Thompson Peak probably represent the only sites where *N. praedicta* survives today in the Trinity Alps and, as far as is known at present, anywhere. The disappearance of these temperature moderating bodies, which is virtually certain to occur with the current climatic warming trend, would be catastrophic for this species, as well as for *N. turmaduodecima*, and likely lead to their quick extinction.

ACKNOWLEDGMENTS

We thank Bret Cristobel, Ecological Data Manager for the North Coast & Cascades Network, U. S. National Park Service, for his help in obtaining a collecting permit (#MORA-2008-SCI-0024, issued to DHK) for work at Mount Rainier National Park, and the California Department of Fish and Game for the permit (#SC-006997, issued to SDS) for collecting *Nebria*. We also thank Norman D. Penney (CAS), Kipling W. Will (University of California, Berkeley), and Michele L. Aldrich for critical and most helpful reviews of our draft manuscript.

Literature Cited

Bänninger, M. 1928. Über die Nebriini. 13. Beitrag zur Kenntnis der Carabinae. *Koleopterologische Rundschau* 14:1–7.

Darlington, P.J., Jr. 1930. A new *Nebria* from Mount Rainier. *Psyche* 37:104–105.

Darlington, P.J., Jr. 1931. A new name for *Nebria vandykei* Darlington. *Psyche* 38:24.

Kavanaugh, D.H. 1971. Up the falls—tarsal modifications in a carabid. Page 16 in *Proceedings of the Nineteenth Annual Meeting of the Entomological Society of Alberta*, 1971, v + 56 pp. [Abstract]

Kavanaugh, D.H. 1979. Studies on the Nebriini (Coleoptera: Carabidae), III. New Nearctic *Nebria* species and subspecies, nomenclatural notes, and lectotype designations. *Proceedings of the California Academy of Sciences*, ser. 4, 42(4):87–133.

Kavanaugh, D.H. 1981. Studies on the Nebriini (Coleoptera: Carabidae), IV. Four new *Nebria* taxa from western North America. *Proceedings of the California Academy of Sciences*, ser. 4, 42(16):435–442.

Kavanaugh, D.H. 1985. On wing atrophy in carabid beetles (Insecta: Coleoptera: Carabidae), with special reference to Nearctic *Nebria*. Pages 408–431 *in* G.E. Ball, ed., *Taxonomy, Phylogeny, and Zoogeography of Beetles and Ants: a Volume Dedicated to the Memory of Philip J. Darlington, Jr. 1904–1983*. Dr. W. Junk Publishers, Dordrecht, Netherlands. xiii + 514 pp.

Ronquist F, and J. P. Huelsenbeck. 2003. MrBayes 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics* 19:1572–1574.

Simon, C., F. Frati, A. Beckenbach, B. Crespi, H. Liu, and P. Flook. 1994. Evolution, weighting, and phylogenetic utility of mitochondrial gene sequences and a compilation of conserved polymerase chain reaction primers. *Annals of the Entomological Society of America* 87:651–701.

Simon, C., T.R. Buckley, F. Frati, J.B. Stewart, and A.T. Beckenbach. 2006. Incorporating molecular evolution into phylogenetic analysis, and a new compilation of conserved polymerase chain reaction primers for animal mitochondrial DNA. *Annual Review of Ecology, Evolution, and Systematics* 37:545–579.

Stone, S. 2008. Beetles on the Rise. *Live from the California Academy of Science* 2008(Winter):8–13.

Copyright © 2009 by the California Academy of Sciences
San Francisco, California, U.S.A.

PROCEEDINGS OF THE CALIFORNIA ACADEMY OF SCIENCES

Series 4, Volume 60, No. 8, pp. 85–88, 2 figs., Appendix May 7, 2009

In Memoriam: Hugh Bosdin Leech (1910-1990)

Paul H. Arnaud, Jr. and David H. Kavanaugh
California Academy of Sciences, 55 Music Concourse Drive, Golden Gate Park, San Francisco, California 94118, USA; Email: parnaud@calacademy.org, dkavanaugh@calacademy.org

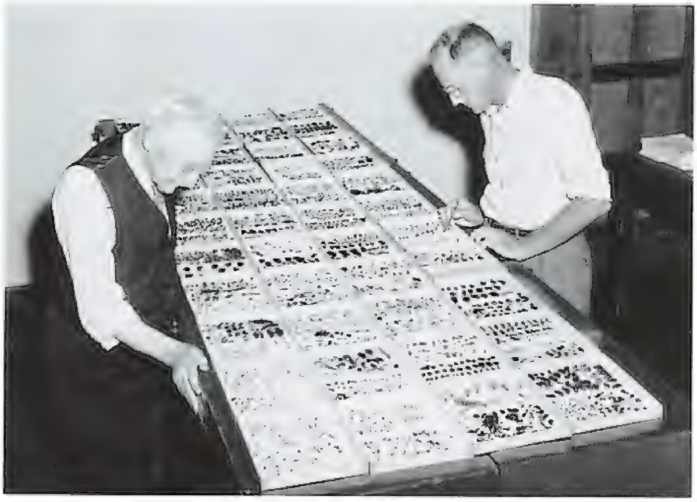


FIGURE 1. Photograph of Hugh Bosdin Leech (right) and Edwin C. Van Dyke (left) examining dried insect specimens on cellucotton layers prior to sorting and preparation (taken at the California Academy of Sciences ca. 1950). N1877 California Academy of Sciences Archives, Special Collections, San Francisco, CA.

Hugh Bosdin Leech (Fig. 1), Curator Emeritus, California Academy of Sciences, an authority on Coleoptera and particularly aquatic beetles, and Curator of Coleoptera at the California Academy of Sciences from 1947 until his retirement in 1975, died on 8 November 1990, at San Rafael, California, from complications attributed to pneumonia and Alzheimer's disease. In addition to his expertise on Coleoptera, he was a curator par excellence and was exceedingly helpful to both students and established re-searchers. He contributed nearly 350 articles and notes in the field of Entomology. By the time of his death, in 1990, 85 insects and related arthropods had been named in his honor by his peers and correspondents.

Hugh B. Leech was born at Kamloops, British Columbia, Canada, on 10 May 1910. His father had emigrated to Canada from Manchester, England, where Hugh's grandfather, Sir Bosdin T. Leech, who served as mayor of Manchester, had been knighted by Queen Victoria in recognition of his influence in the building of the Manchester Ship Canal. Hugh received his early education in Lakefield, Ontario, at the Lakefield Preparatory School, and in British Columbia at the Vernon Preparatory School in Vernon, and the Salmon Arm High School in Salmon Arm. He earned his B.Sc. degree from the University of British Columbia, Vancouver, in 1933, and his M.Sc. degree from the University of California, Berkeley, in 1938. At Berkeley he was associated with Professor E.O. Essig; and it was there that he first met Dr. Edward S. Ross.

Hugh's interest in insects and natural history began at an early age on his father's farm at Salmon Arm. He was encouraged by his parents — by what Leech once published as his father's keen interest in "birds and plants, and [his father] had a remarkably broad yet detailed knowledge of the families and habits of insects" and to his mother "with her love of flowers, books, and the beauty of the countryside." (H.B. Leech, pers. comm.) During his high school years, Hugh was introduced to Ralph Hopping at the Forest Entomology Laboratory in Vernon, British Columbia;

and under Hopping's guidance, his interest in and knowledge of beetles grew rapidly. Ralph Hopping had been lured from his position with the United States Forest Service, leaving California in 1919 to serve as Forest Entomologist, Dominion Department of Agriculture, at Vernon, where he was free to publish original observations. He had not been allowed to published under his own name in the United States. Nearly all of the 36 articles that he published appeared after 1920. Hopping retired in 1939, died on October 29, 1941, and it was his wish that his collection, the major portion of which was amased prior to his move to Canada, would be donated to the California Academy of Sciences. The collection, consisting of 97,197 specimens housed in 411 boxes, was transferred to the Academy in May, 1948 by Hugh and Dr. Edward S. Ross, who succeeded in packing it all into one Academy suburban. A representative collection of British Columbia material naturally remained in Canada.

Hugh's knowledge of Coleoptera and other insects was such that, from 1930 to 1947, whenever he was not attending the university, he was employed at the Forest Entomology Laboratory in Vernon. Hugh became well known to Bay Area entomologists through his matriculation at the University of California, Berkeley in 1937 and 1938. His wife of 55 years, Frances recalls how the two years at Berkeley were lean years "where a little bit of money had to go a long way." (pers. comm.) Their first son, Robin, was born in Berkeley while Hugh was completing his Master of Science Degree.

Following the 2nd World War, in 1947, with the expansion of the staff of the Entomology Department of the California Academy of Sciences, Hugh was selected as a new Assistant Curator to join the existing staff of Drs. Ross and Edward L. Kessel. The department did not have either a secretary or technical assistants at this time. Hugh was placed in charge of the largest section of the collection — the beetles (Coleoptera) — probably over a million specimens. On a visit to the Academy in 1947, one of us (PHA) can recall how Dr. Edwin C. Van Dyke (1869–1952), then Curator Emeritus, was pleased to announce that Hugh B. Leech would be arriving soon as a new Curator to the Department. Dr. Van Dyke, a medical doctor and former Professor of Entomology at the University of California, Berkeley, had given his collection of nearly a quarter of a million specimens to the Academy; and his collegue, Dr. Frank E. Blaisdell (1862-1946), former head of the Stanford University Cooper Medical School, had likewise presented his collection of 200,000 beetles to the Academy. As indicated by the avocational interests of these two MDs, at the turn of the century there were relatively few positions in the field in Entomology, so that it was often medical doctors and other professionals that were active in the discipline.

As a matter of fact, in addition to the million Coleoptera, Hugh curated other portions of the Academy collection as well, including the Hymenoptera. He also served as Acting Chairman during the many long absences of Dr. Edward S. Ross in his world travels. As was the departmental policy for some staff at the time, Hugh did the writing for his research and publications at home. As his son has written, "He reserved his 'Academy Time,' as he called it, for correspondence, curating and visitors" (Leech 1991:95). Much of his field work was done on family vacations and on weekends. Exceptions included a trip to mainland Mexico in 1948 with Dr. Ross, a particularly productive trip to Arizona in 1952 with J. Wagener Green, a Belvedere Scientific Expedition to Baja California in the winter of 1958–1959 by land with Dr. Alan E. Leviton (see Fig. 2), and a trip to northern Baja California with one of the authors (PHA) in 1963.

Hugh had a favorite work table adjacent to his desk cubicle at which he would sit with visitors to the department. He would accomplish some of the necessary curation, such as the pinning of outgoing or incoming loans, while still involved in conversation. During his career he helped hundreds of students and research workers. As Kavanaugh and Arnaud have published (1981) "He is orderly and precise, tough-minded, independent, but with a keen sense of humor which permits him to

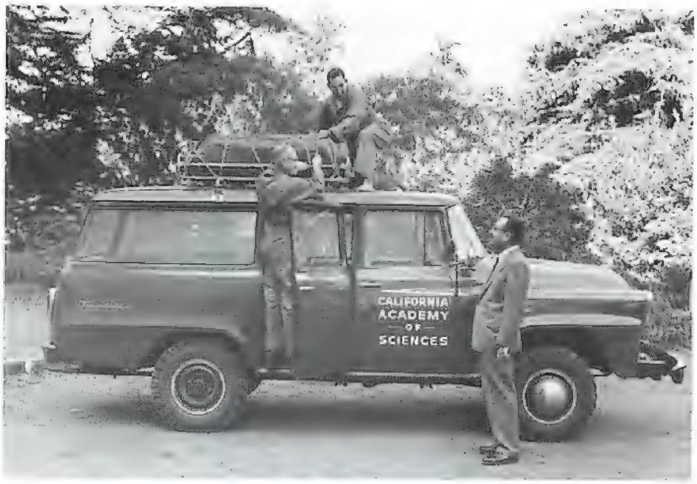


FIGURE 2. Photograph of Hugh Bosdin Leech (standing in doorway) and Alan E. Leviton (Assist. Curator of Herpetology, on roof) preparing the Academy field vehicle for the Belvedere Scientific Expedition to Baja California in the winter of 1958-1959, with Academy Director, Robert. C. Miller, (standing at right) supervising. N19796A California Academy of Sciences Library, Special Collections, San Francisco, CA

keep details in prespective. He is also a superb correspondent, adept at handling the kinds of exchange that characterize the curator's role as interface between collection resources (both specimens and information) and the users of those resources. A trusting person, Hugh has been willing to take a chance on the unproven. Consequently, he has been extremely helpful to students or others just getting started in insect systematics by providing information or loaning specimens when other curators might have refused to do so; and he has done much to foster careers in entomology through his continued encouragement to colleagues, both young and old." He was rightly called a "Curator's Curator."

Following their retirements Hugh and Frances moved inland from their home in the foggy Seacliff area of San Francisco into a newly built log house on 44 acres of land on Howell Mountain, just east of Angwin, in Napa County, California. From this new home they had a beautiful view overlooking the tranquil Pope Valley. It was here that Hugh could develop his gardens with hand tools and hours of his labor. He could collect insects in the vicinity of his home and continue the rearing of insects inhabiting dead wood which led to a wealth of precise information on insect/host plant associations and interspecific interactions. Hugh could also continue his life-time interest in stamps - he was one of the leading authorities on pre-Communist Chinese stamps, and was an active member of San Francisco's China Clipper Stamp Society (serving as its President). Regrettably the distance of his home on Howell Mountain in Napa County from the Academy precluded frequent visits to this institution during his retirement.

On the occasion of his seventieth birthday Hugh was honored with a special issue of *The Pan-Pacific Entomologist* (volume 57, number 1, pages 1–320, 1981). A total of 24 papers was presented in that issue, 23 of which dealt the taxonomy, biology, and/or distribution of aquatic Coleoptera, the field of Hugh's principal research interest. Included were the descriptions of three new genera and five new species named in Hugh's honor. The 24th paper (Kavanaugh and Arnaud 1981) was a biography, which described Hugh's career and included lists of his publications, taxa that he described, and taxa named in his honor. Because Hugh's last paper was published in 1978, the lists of his publications and described taxa provided in 1981 remain complete. However, an additional 17 new species and three new genera named in his honor are listed here in Appendix A.

Hugh was survived at the time of his death by his wife Frances Orchid Quail Leech, of Novato, California, three sons — Dr. Robin E. Leech, of Edmonton, Canada, William H. Leech of Santa Ana, California, Thomas S. Leech of Novato, California - one daughter - Mary Kathleen (Leech) Huffaker from near Alpine, California — and by six grandchildren, living in both Alberta and California, and two great-grand children.

Literature Cited

KAVANAUGH, D.H., AND P.H. ARNAUD, JR.. 1981. Hugh Bosdin Leech—a curator's curator. *Pan-Pacific Entomologist* 57:2–42.

LEECH, R.E. 1991. Hugh Bosdin Leech (1910–1990). *The Coleopterists Bulletin* 45:95–96.

APPENDIX A. ADDITIONAL TAXA NAMED IN HONOR OF HUGH B. LEECH[2]

CLASS INSECTA

Order Epheroptera

Family Baetidae
Baetis leechi Day, 1954 (California)

Order Coleoptera

Family Chrysomelidae
Proctophana leechi Moldenke, 1981 (Brazil)
Family Curculionidae
Pseudothysanoes leechi Wood, 1980 (California)
Family Dermestidae
Dermestes leechi Kalik, 1952 (India)
Family Dytiscidae
Desmopachria leechi Young, 1981 (Florida)
Hughbosdineus Spangler new genus, 1981
Hughbosdineus leechi Spangler, 1981 (Venezuela)
Hydroporus leechi Gordon, 1981 (California)
Oreodytes leechi Zimmerman, 1985 (Alaska)
Family Elmidae
Huleechius Brown new genus, 1981
Xenelmis leechi Perkins and Steiner, 1981 (Peru)
Family Eubriidae
Ectopria leechi Brigham, 1981 (Illinois)
Family Hydraenidae
Hughleechia Perkins new genus, 1981
Hughleechia giulianii Perkins, 1981 (Australia)
Hydraena leechi Perkins, 1981 (Arizona)
Limnebius leechi Perkins, 1980 (California)
Ochthebius leechi Perkins and Wood, 1978 (California)
Family Hydrophilidae
Hydrochara leechi Smetana, 1980 (New Mexico)
Laccobius leechi Cheary, 1971 (California)

Order Diptera

Family Anthomyiidae
Delia leechi Griffiths, 1993 (California)

---

[2] Taxa not included in Kavanaugh and Arnaud (1981, Appendix C)

Copyright © 2009 by the California Academy of Sciences
San Francisco, California, U.S.A.

PROCEEDINGS OF THE CALIFORNIA ACADEMY OF SCIENCES
Fourth Series

Volume 60, No. 9, pp. 89–174, 5 figs., 1 table May 7, 2009

Georgius Agricola, *De Animantibus Subterraneis*, 1549 and 1556: A Translation of a Renaissance Essay in Zoology and Natural History

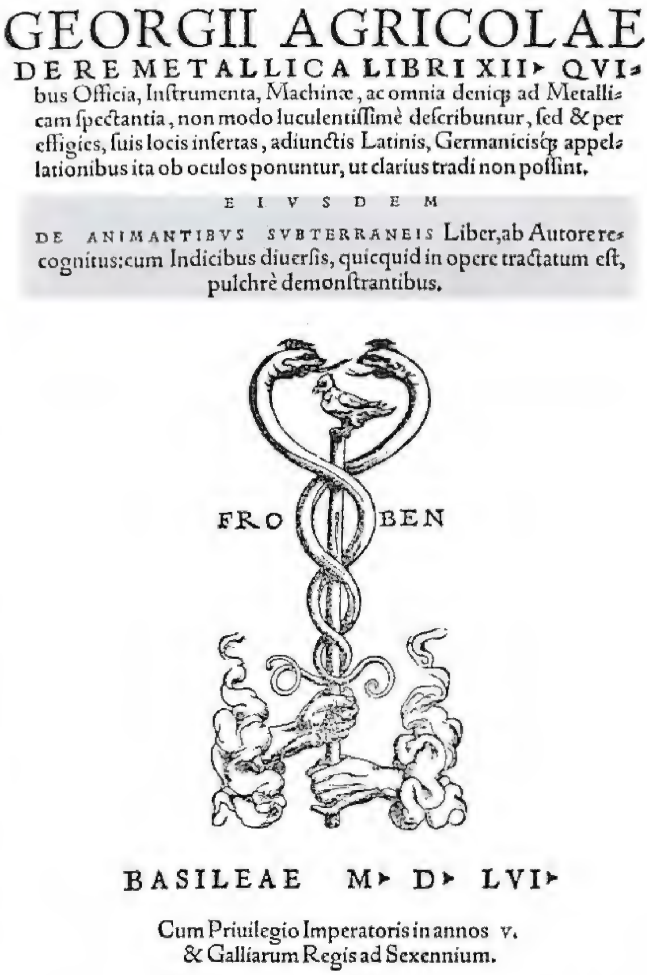
Michele L. Aldrich[1,3], Alan E. Leviton[1], and Lindsay L. Sears[2]
[1] *California Academy of Sciences, 55 Music Concourse Drive, San Francisco, California, 94118; Email: maldrich@smith.edu; aleviton@calacademy.org;* [2] *Department of Classics, Cornell University, Ithaca, New York 14853; Email: lls67@cornell.edu*

Georgius Agricola (1494-1555) is well known for his geological publications, especially his masterpiece, *De Re Metallica* (1556), over 500 pages of text illustrated with more than 250 beautiful and instructive woodcuts. Historians of medicines also have studied him for his work on disease. But in 1549, he published a short treatise on animals known to exist in the subsurface. This essay is a compendium of what Greek, Latin, and medieval authorities wrote about these animals, but, unlike many of his contemporaries, Agricola supplemented those writings with his own observations, and he posed questions about the existence of some of the fanciful beasts described by his forbearers. Of special interest to paleontologists and zoologists is an "index" at the end where Agricola groups animals by their form of locomotion—walking, crawling, swimming, flying, burrowing—as well as the occasional use of binomens, following in the footsteps of several contemporary herbalists. *De Animnantibus Subterraneis* appeared again as an appendix to *De Re Metallica*, an updated reprint of the 1549 work set in a folio format. Curiously, when Lou Henry Hoover and Herbert Hoover published their masterful annotated English translation of *De Re Metallica* in 1912, they did not include the essay on animals. Consequently, it is not well known to English-speaking scholars, although it was cited by some of Agricola's contemporaries, including Conrad Gessner. Then why has Agricola been ignored? Agricola's *De Re Metallica* was copiously illustrated, as were the works of Gessner and Ulisse Aldrovandi. Thus, even those not fluent in Latin could, with some effort, understand these authors' intentions by reference to the pictures. But not so with Agricola's *De Animatibus Subterraneis*, which was not illustrated. However, neglecting *De Animantibus Subterraneis* makes Agricola too much of a specialist, whereas as a Renaissance scholar his interests spanned many disciplines. To increase the awareness of Agricola's essay on subterranean animals among English-speaking zoologists and historians of science, we offer a functional translation of the 1556 version of his work, which represents his final contribution to the field of biology.

In 1912, Lou Henry Hoover and Herbert Clark Hoover published an annotated translation of Georgius Agricola's *De Re Metallica* (1556), a masterpiece on Renaissance mining. They included facsimiles of the approximately one hundred woodcuts, making a very attractive volume of which 3,000 copies were printed (a Dover reprint of their edition appeared in 1950, further increasing the knowledge and availability of Agricola's work).

---

[3] Research Associate, Department of Herpetology and Center for the History and Philosophy of Science, and Consulting Editor, Scientific Publications, California Academy of Sciences.



GEORGII AGRICOLAE
DE RE METALLICA LIBRI XII. QVIbus Officia, Inſtrumenta, Machinæ, ac omnia deniq; ad Metallicam ſpectantia, non modo luculentiſſimè deſcribuntur, ſed & per effigies, ſuis locis inſertas, adiunctis Latinis, Germanicisq; appellationibus ita ob oculos ponuntur, ut clarius tradi non poſſint.

EIVSDEM

DE ANIMANTIBVS SVBTERRANEIS Liber, ab Autore recognitus: cum Indicibus diuerſis, quicquid in opere tractatum eſt, pulchrè demonſtrantibus.

FRO BEN

BASILEAE M. D. LVI.

Cum Priuilegio Imperatoris in annos V.
& Galliarum Regis ad Sexennium.

FIGURE 1. Title page of Agricola, *De Re Metallica* (1556), with the reference to the DAS chapter shaded (by the authors for refernce).

The Hoovers did not include all of the 1556 book, however. The original, as its last chapter, also contained *De Animantibus Subterraneis* (hereafter DAS), a revised edition of Agricola's essay on underground animals that first appeared in 1549 as a separate treatise. DAS was also not included in the 1557 translation of *De Re Metallica* from Latin to German, but in the modern German compilation and translation of all of Agricola's publications, the editors prepared a German translation for the first time (1961) to our knowledge. In the following pages, Lindsay Sears, a graduate student in Classics at Cornell University, presents the first translation of DAS into English. Although she had the German translation available to her, she translated directly from a photocopy of the 1556 Latin version that is in the Rare Book Room of the United States Library of Congress.

The English text that appears below belongs to the functional tradition of translation; it is designed to be of use to today's zoologists and historians of science. We are well aware of the limitations of this style, as outlined by translation theorists such as Andre LeFevere (1992) and Maria Tymoczko (1999). In preparing for a modern readership, one must be on guard not to alter the text to make Agricola into a 21st century, or even an 18th century, zoologist. Also, in following the rules of modern English, we have changed Agricola's language in ways that do not reflect Renaissance style, for example, by eliminating the double negatives that were considered a hallmark of elegant writing in his day. Having said this, we did do some light editing, such as substituting "that" for "which," in line with present-day rules of English grammar, and selecting of several more appropriate English synonyms for such Latin terms as *At*, meaning but, yet, on the contrary, at least, and *contra*, meaning against, opposite to, on the contrary, otherwise, on the other hand, this to render the text more readable. We include a facsimile of the 1556 text for those who prefer the original Latin.

GEORGIUS AGRICOLA: A BIOGRAPHICAL SKETCH

Georgius Agricola Latinzed his name as an adult; he was born as Georg Bauer or Pawer in Glauchau, Germany on 24 March 1494. His father was a master cloth maker; one of Agricola's

FIGURE 2. Woodcut image of Georgius Agricola.

brothers continued in that trade and another became a priest. Details of his early schooling are not definitively known but he attended Latin schools in the region before enrolling at the University of Leipzig, 1514–1518. In those years, the most intense new scholarship at Leipzig centered on Greek and Hebrew; Agricola learned Greek and as a schoolmaster in Zwickau (1518–1522), started instruction in the language there and published his first work, a Latin grammar. When Lutheran reformers made life for the Catholic schoolmaster uncomfortable, Agricola returned briefly to Leipzig to start training as a physician and then departed for Italy (1523–1526), where he studied medicine and also worked with an international group of scholars translating and editing works by Galen and Hippocrates. In 1526, he set up as a physician and apothecary in the silver mining town of Joachimstahl, Czechoslovakia. There he began his life's work on recovering ancient knowledge of science and technology as applied to the underground, mostly to mining but also to the topic at hand, subterranean animals. (Hannaway 1992.)

In 1530, Agricola published *Bermannus*, a dialogue among two physicians and a mining expert discussing mining methods and the ailments of miners and how to treat them. The book brought ancient texts in Greek and Latin to bear on the problem, merging that knowledge with modern experience. Thanks in part to a letter of endorsement by Erasmus, whom Agricola had met years earlier, it was published in Basel by a printer with an international distribution. Shortly thereafter, Agricola moved to the mining city of Chemitz as town physician. He successfully invested in mining partnerships, building the wealth that supported his life as a scholar. He continued to publish books that merged ancient and contemporary knowledge of mining, mineralogy, and paleontology, culminating in his masterpiece, *De Re Metallica* (1556), a book that included the revised version of DAS. During the 1540s and 1550s, he also became involved in civic and political life on the municipal, regional, and national level. This included his heroic work as a physician during the plague epidemic in Saxony in 1552–1553, memorialized in his one medical book, *De Peste* (1554). He died in Chemitz on November 21, 1555. (Dibner 1958; Wolsdorf 1970.)

DAS IN THE CONTEXT OF ITS DAY

DAS is Agricola's compendium of ancient (Greek and Latin, plus a few medieval compilers) knowledge about animals that live underground for at least part of their lives. He had spent a life time immersing himself in ancient texts, but brought a critical view and his own observations to bear on what he learned from them.

Agricola's essay differed from two earlier traditions of writing about animals. Medieval bestiaries were manuscripts, not printed books, and thus limited to local readership. They were a form of allegorical Christian literature in which the stories about animals illustrated moral lessons and the handiwork of God. Bestiaries were often beautifully illustrated with carefully executed hand-painted drawings in full color. On the other hand, there are no pictures in DAS, even though *De Re Metallica* was richly endowed with images of mining. DAS also differed from medieval encyclo-

TABLE 1. Agricola's List of Authorities[4] for *De Animantibus Subterraneis*[1]

Claudius Aelianus, 175–235, Roman rhetorician
Albertus Magnus, 1206–1280, German theologian
Alexander Aphrodisianus, fl. 190–220, Greek philosopher
Ammonius, 435–517, Greek philosopher
[5] Aratus, 315–206 BC, Greek poet
Aristotle, 384–322 BC, Greek philosopher
Aristophanes, 446–386 BC, Greek dramatist
Athenaeus, fl. 190–210, Greek grammarian
[5] John Cassianus, 360–435, Roman theologian
Flavius Charisius, fl. 4th century AD, Latin grammarian
Cicero, 106–43 BC, Roman statesman and orator
Lucius Columella, 4–70, Roman agricultural writer
Cornelius Tacitus, 56–117, Roman historian
Pedanius Dioscorides, 40–90, Greek physician and botanist in Rome
Galen, 129–200, Roman physician
Homer, 8th c. BC Greek poet(s)
Horace, 65–8 BC, Roman poet
Jornandes, 6th c. Roman historian
Lucanus [Lucan], 39–65, Roman poet
Martialis, ca. 40–105, Roman poet
Nicander, 2nd c. BC, Greek physician
Oppianus, 2nd/3rd c. AD, Greek poet on fishing and hunting
Ovid, 43 BC–17 AD, Roman poet
Plautus, 254–184 BC, Roman playwright
Pliny the Elder, 23–79, Roman naturalist
Michael Psellos, 1017(or 18)–(after) 1078, Byzantine writer
Seneca, 4 BC–65 AD, Roman humanist
[5] Servius, fl. 420 AD, Latin grammarian
Strabo, 63 BC–24 AD, Greek geographer
Theophrastus, 370–285 BC, Greek philosopher
Marcus Varro, 116–27 BC, Roman historian
Virgil, 70–19 BC, Roman poet
Xenophon, 431–355 BC, Greek historian

[4] Names have been modernized and Anglicized to permit searching. Dates are from Web sources and may not be reliable; AD is assumed unless otherwise mentioned. [5] Listed in 1556 edition but not in 1549

pedias, which were reference works that were usually alphabetically arranged without attempts at classification schemes.

His respect for ancient texts led Agricola into some problems in DAS. For one, he reported uncritically on some fables about animals, such as foxes that fish with their tails (Fig. 3). This legend can be traced back at least to Claudius Aelianus (Gudger 1955), who is one of his sources. Second, his text is dotted with fabulous animals — dragons, basilisks, footless birds — that were also common in other 16th century zoological works, such as those by Conrad Gesner [also as Gessner] and Ulysses Aldrovandi (Fig. 4). Mystical beasts were not eliminated from zoological writings until those books came to include only animals that had been observed by the naturalist. (Nigg 1999.)

Sometimes Agricola reports on beasts in such a way that the reader senses he is paraphrasing sources but not necessarily endorsing the idea. Consider, for example, his discussion of devils that live underground, a notion he attributes to theologians without further comment. (A good Catholic, Agricola wrote this essay and his other books in such a way as to receive the Church's imprimatur, an aid to their acceptance that did not always come to Aldrovandi [Gould 2003]). In other cases, throughout the essay, he supplements with his own observations, even contradicting what his forebearers had said (e.g., Lucanus, p. 497, para. 1; Nicander, p. 496, para. 4; Pliny, p. 496, para. 4; Theophrastus, p. 501, para. 6). As Owen Hannaway (1992) said of all of Agricola's writing, he combined humanistic, literary scholarship with scientific, observational study.

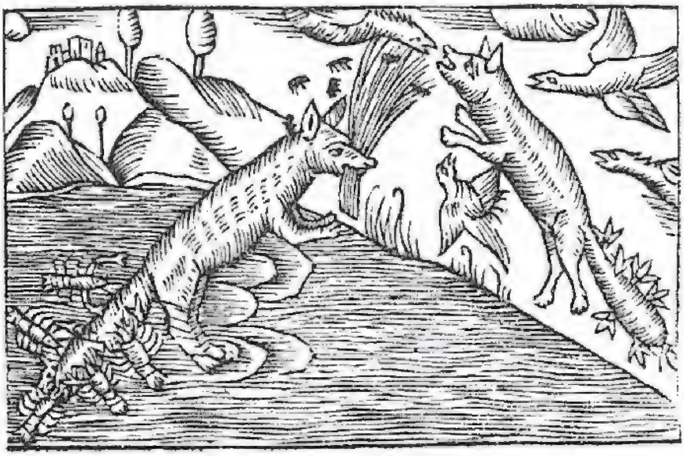


FIGURE 3. From Olaus Magnus (1555), a fox fishing with its tail (after Gudger 1953).

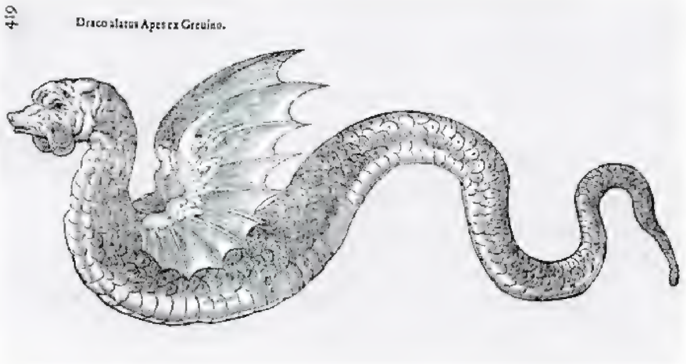
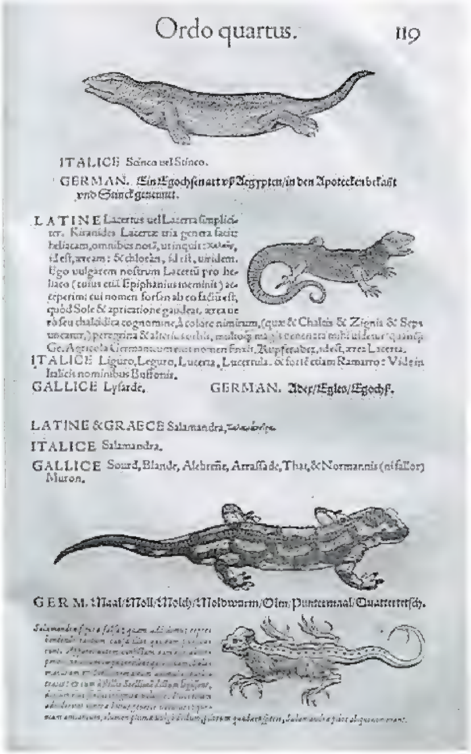

419
Draco alatus Apes ex Greuino.

FIGURE 4. Draco alatus (from Aldrovandi, 1640, ex Greuini, 1571).

Agricola categorized underground animals into those who stay in the earth during the day or night, those that live underground, or at least under cover, such as in hollows in trees, during part of the year to avoid heat or cold, and those that are under the surface all of the time. There was some overlap among these categories. He then arranges the animals into loosely connected groups, such as weasels, owls, and fish. Humans are discussed as animals through the book. In describing individual animals, Agricola remarks on their behavior — feeding, prey/predator relationships, hibernation, migration, habitat choices and changes, and some observations on reproduction — but not for all his cases. In dealing with morphology, he notes shape, size, and color, but adds little about physiology or internal organs. He does not list all features for each beast; this was not a reference work, but an essay. DAS approaches a modern natural history, but it is more discursive and in that sense closer to the storytelling tradition of the medieval bestiary. With its focus on one environment, the underground, and attention to the actions among animals, DAS has the feel of an ecological approach. Agricola wrote in a lively style, drawing good word pictures of animals and enjoying puns on their names.

In his other publications, Agricola had included classification schemes for natural materials such as minerals and ores. As for zoology, histories of classification tend to go from Aristotle to Linnaeus nonstop, with the important exception of Hunemorder (1983). That makes it hard to position DAS, which is not primarily a work of taxonomy in the first place. However, the way Agricola indexed animals in the back of DAS provides clues as to how he classified them (see below). One such list was of Latin names with their German counterparts alongside. As Hammaway (1992) remarked, this was a common feature in most of Agricola's books and provided a way for the reader to go from the ancient to the contemporary, from words and language to things and observation, from humanities to science.

Another index grouped animals by locomotion, those that walked, flew, swam, or crawled. Two other groups, worms and dragons, were listed separately. Aristotle had tried a scheme based on motion and abandoned it (Pellegrin 1982). Agricola's system ran into some problems, notably with reptiles and amphibians. Frogs and crocodiles swim and walk, sea snakes swim but other snakes slither about on land. Many of the shifts in where beasts appeared on the list between the 1549 edition of DAS and the 1556 version occurred in these groups, reflecting Agricola's awareness of the problem. Another issue arose with bats, which flew but were otherwise akin to mice and other rodents. And, although Agricola carefully details how much more closely bats resemble mammals, i.e., "mice," than birds, he lists them among the "flying" animals in his Index and groups them with birds on page 485. It was not until the 17th century that the assignment of bats to mammals was settled by John Willoughby.


Ordo quartus. 119

ITALICE Scinco uel Stinco.

GERMAN. Ein Egochſenart vß Egypten/in den Apoteckern bekañt vnd Stinck genennt.

LATINE Lacertus uel Lacerta ſimpliciter. Kiranides Lacertæ tria genera facit: heliacam, omnibus notã, ut inquit: χαλκῆν, id eſt, æream: & chloran, id eſt, uiridem. Ego uulgarem noſtrum Lacertũ pro heliaco (cuius etiã Epiphanius meminit) acceperim: cui nomen forſan ab eo factũ eſt, quòd Sole & apricatione gaudeat. Aerea uerò ſeu chalcidica cognomine, à colore nimirum, (quæ & Chalcis & Zignis & Seps uocatur,) peregrina & alterius orbis, [illegible] Ge. Agricola Germanicum ei nomen fecit, Kupferader, id eſt, ærea Lacerta.

ITALICE Liguro, Leguro, Lucerta, Lucertula. & fortè etiam Ramarro: Vide in Italicis nominibus Buffonis.

GALLICE Lyſarde. GERMAN. Ader/Egles/Egochs.

LATINE & GRAECE Salamandra, σαλαμάνδρα.

ITALICE Salamandra.

GALLICE Sourd, Blande, Alebrenc, Arraſſade, Thac, & Normannis (ni fallor) Muron.

GERM. Maal/Moll/Molch/Molwarm/Olm/Punttermaal/Quattertetſch.

[illegible]

FIGURE 5. Images of amphibians and reptiles (from Gesner, 1560).

Agricola's lists demonstrate a casual and partial use of binomial and trinomial names (e.g., *Mus alpinus, Mus araneus, Mus agrestis, Mustela domestica, Mustela sylvestris, Rana rubeta, Rana temporaria*, and others (see below)). Binomialism was gradually introduced well before the 18th century. Philosophers of science do not agree on whether Aristotle conceived of what are now termed genus and species (Pellegrin 1982). Isidore, for instance, employed some binomens in the 7th century, and by the 16th century (Hunemorder 1983), they were as common in Gesner and Aldrovandi as in Agricola. Nevertheless, the most important breakthrough occurred with Linnaeus, who applied the concept of genus and species not here and there but systematically throughout the entire plant and animal community.

DAS's influence on subsequent zoology was modest. Because he wrote of underground animals, he emphasized groups that had been relatively neglected in earlier works. George and Yapp (1991) document the scant attention given these animals in medieval bestiaries. Gesner and Aldrovandi both referred to Agricola's essay in their major compendia. Linnaeus did not cite Agricola, but he did cite the other two. DAS did not attract wide attention in part because, unlike the other Renaissance zoologies, for instance, Gesner, Greuini, and Aldrovandi, it was not illustrated. This contrasts sharply to the widespread recognition afforded *De Re Metallica*, with its numerous beautiful and instructive woodcuts. Historians of science will appreciate DAS for the new dimension it gives to Agricola. When added back to *De Re Metallica*, the treatise changes Agricola from a geologist to an earth scientist — a scholar who studied the animals as well as physical structure of the earth.

Michele L. Aldrich, Alan E. Leviton, and *Lindsay L. Sears*
April 2009

ACKNOWLEDGMENTS

First and foremost, we want to thank Thalia Pandiri (Classics Department, Smith College) who recommended Lindsay Sears as the translator of DAS, thus allowing for an expansion of our original and less ambitious project. Maria Tymoczko (Celtic Studies, University of Massachusetts at Amherst) advised us on translation theory. Many librarians contributed, notably Larry Currie (California Academy of Sciences Library), Margaret Kieckhefer (Library of Congress), Jane Clayton (Neilson Library, Smith College). and the staff of the Marriott Library (University of Utah), Kroc Library (Cornell University), and the Rare Books Division of the Library of Congress. Our good friend Kraig Adler provided access to Gesner's Icones, and Hallie Brignall (California Academy of Sciences) read the entire work and provided thoughtful comments. Lastly, we take special notice of the generosity of our colleague Michael T. Ghiselin (California Academy of Sciences) who reviewed the manuscript and given his knowledge of general natural history, of Central European geography and Renaissance history, and, not the least, Medieval Latin, he offered insights and suggested revisions for which we are most grateful.

REFERENCES

[NB: Librarians give Agricola's first name variously as Georg, Georgii, Georgio, and Georgius.
His name on the title pages of his works is given as Georgius Agricolae, which is correct,
but if it is cited as Agricola, then Georgius is correct.]

Agricola and *De Animantibus Subterraneis* (1549, 1556)

AGRICOLA, GEORGIUS. 1549. *De Animantibus Subterraneis Liber*. H. Froben, Basil, Switzerland. 79 pp., plus 30 unnumbered pages of index and name list.

AGRICOLA, GEORGIUS. 1556. *De re metallica libri XII: quibus officia, instrumenta, machinae, ac omnia denique ad metallicam spectantia, non modo luculentissim describuntur, sed & per effigies, suis locis insertas, adiunctis latinis, Germanicisque appellationibus ita ob oculos ponuntur, ut clarius tradi non possint: eiusdem De animantibus subterraneis liber / ab autore recognitus: cum indicibus diuersis, quicquid in opere tractatum est, pulchre demonstrantibus*. H. Froben, Basil, Switzerland. 538 pp.

AGRICOLA, GEORGIUS. 1961. "De Animantibus Subterraneis" [1549 and 1556]. Pages 139-231 *Georgius Agricola – Ausgewählte Werke*, vol. 6, Hans Prescher, ed. Staatslichen Museum für Mineralogie und Geologie zu Dresden. Deutscher Verlag der Wissenschaften, Berlin, Germany. [A modern German translation with editorial commentary.]

Secondary References

ALDROVANDI, ULISSE. 1640. *Serpentum, et draconum historiae libri duo Bartholomaeus Ambrosinus ... summo labore opus concinnauit ... cum indice memorabilium, nec non variarum linguarum locupletissimo*. C. Ferronium, Bononiae [Bologna], Italy. 427 + [30] pp., 4 pls.

DIBNER, BERN. 1958. *Agricola on Metals*. Burndy Library, Norwalk Connecticut, USA. 128 pp.

GEORGE, WILMA, AND BRUNSDON YAPP. 1991. *The Namine of Mythical Beasts. Natuural Hisatory in the Medieval Beastiary*. Gerald Duckworth & Co., London, UK. 231 pp.

GESNER, CONRAD. 1560. *Icones Animalium quadrupedum viviparorum et oviparorum, quae in Historiae animalium Conradi Gesner libro I. et II. describuntur, cum nomenclaturis singulorum latinis, graecis, italicis, gallicis, et germanicis plerunque, et aliarum quoque linguarum, certis ordinibus digestae*. Second edition. Tiguri [Zurich], excudebat C. Froschouerus.

GOULD, STEPHEN JAY. 2003. *The Hedgehog, the Fox, and the Magister's Pox; Mending the Gap Between Science and the Humanities*. Harmony Books, New York, New York, USA. xiv + 274 pp., illus.

GREUINI, IACOBI. 1571. De Venenis, Libr Primus: In quo de Natura Animalium venenosorum, & de Theriacis, hoc est, contra morsus illorum remedys, agitur : autore Iacobo Greuino, Medico Parisiensi, & Hieremia Martio, Medico Augustano interprete. Antverpiae [Antwerp]: ex officina Christophori Plantini. 19 [unnumbered] + 364 pp., illus.

Gudger, E.W. 1953. On certain small terrestrial mammals that fish with their tails. *American Midland Naturalist* 50:189-201.

Hannaway, Owen. 1992. "Georgius Agricola as Humanist." *Journal of the History of Ideas* 53:553-560.

Hoover, Herbert Clark, and Lou Henry Hoover. 1912. *Georgius Agricola De re Metallica, translated from the 1st Latin edition of 1556, with biographical introduction, annotations and appendices upon the development of mining methods, metallurgical processes, geology, mineralogy and mining law, from the earliest times to the 16th century*. The Mining Magazine, London, England. 640 pp.

Hunemorder, Christian. 1983. "Aims and Intention of Botanical and Zoological Classification in the Middle Ages and Renaissance." *History and Philosophy of the Life Sciences* 5:53-67.

Lefevere, Andre. 1992. *Translating Literature: Practice and Theory in a Comparative Literature Context*. Modern Literature Association of America, New York, New York, USA. 165 pp.

Nigg, Joseph, ed. 1999. *The Book of Fabulous Beasts*. Oxford University Press, New York, New York, USA. 408 pp.

Pellegrin, Pierre. 1982, 1986. *Aristotle's Classification of Animals: Biology and the Concept of Unity of the Aristotlean Corpus* (translated from French by Anthony Preus). University of California Press, Berkeley, California, USA. 235 pp.

Tymoczko, Maria. 1999. Translation in a Postcolonial Context. Early Irish Literature in English Translation. St. Jerome Publ., Manchester, UK. 336 pp.

Wolsdorf, Helmut M. 1970. Agricola, Georgius. Pages 77–79 *in* Charles Coulston Gillispie, ed., *Dictionary of Scientific Biography*. Charles Scribner's Sons, New York, New York, USA.

Editors' note: In using page breaks (numbers in [xxx]), it must be borne in mind that the breaks may not exactly coincide with the original Latin text because of the translation and reordering of words. Thus, several words of Latin text may, in fact, appear on the following page and not precisely where the break is indicated. However, this should not be a problem inasmuch as the "spill over" never exceeds a half dozen words. Also, it must be noted that paragraph breaks are based on "best estimates" to enhance readibility; there are relatively few clear-cut paragraph breaks in Agricola's *De Animantibus Subterraneis*. Lastly, we have included in brackets and boldfaced [**xxxxx**] cross-references to Agricola's Index for animal names; in several instances, we have added a present-day common or vernacular name in brackets. The latter are identified by "eds." appended to the addition. Also in brackets, but not boldfaced, are comments indicating our uncertainty as to what animal Agricola had in mind because we have been unable to trace the identity. Furthermore, Agricola often used colons, not semicolons (which did not come into use until 1644) or periods, where in modern English, one or the other would be more appropriate. In this translation, we have retained Agricola's colons in places where semicolons would be more appropriate but for readability have introduced periods to end a sentence.

De Animantibus Subterraneis

Translation of G. Agricola, *De Animantibus Subterraneis* (1556 edition)
by Lindsay L. Sears, July-August 2007

Letter of Dedication

Georgius Agricola sends greetings to Georgius Fabricius

[478] Although Aristotle wrote two books on plants, nevertheless these did not deter his student 478 Theophrastus from explaining his own thoughts concerning these same plants in many books. And Theophrastus himself did not extinguish the zeal and ardor for Dioscorides by means of such great knowledge and such great abundance, but in service to posterity, he entrusted the features and powers of certain trees and plants, learned by long and extensive practice, to the pages of literature. For his studies would have held him poorly, if it had been permitted for people living in later ages to add nothing to those things that had been discovered by the ancestors. Certainly if the Greeks had accepted this unfair rule, no skill, no knowledge, and no discipline could have been carried out. For this reason, although Aristotle put forth many books, in which he pursued the natures, parts, and origins of animals by way of reason, nevertheless he was unwilling to take away those things already dedicated to philosophy, nor should he have, not only out of the zeal for seeking knowledge and revealing to later generations the natures of these animals, about which he wrote little or nothing, but also a zeal for discussing places, which he had not explained enough in these books.

And in this way, even among the Greeks, Oppianus wrote about fish, and Porphyrius and Aelianus wrote about the nature of animals. Likewise among the Romans, Ovid wrote about fish, and Pliny wrote about almost all of the animals. I am following in the footsteps of these writers, since I have explained in many books those subterranean things that lack life, so that I might sum up the established reasoning, as much as it can be done, and I have also described the subterranean animals: not only those which live in the earth almost all the time, but also those that are accustomed to hide in the earth during certain seasons of the year. Moreover, in the same way, I wished to explain more extensively both the forms of certain animals either unknown to Aristotle and others or explained very little, and the place where these animals hide themselves during the winter months. If I show this book to you who are learned in the early literature of the Greeks and Romans, you will examine carefully the natures of animals and you have already grasped the knowledge of many of them, and I will show this more easily, as I hope, to others who especially enjoy the study of secret matters. Farewell from Chemnitz, written on the Ides of August in the year 1548.

De Animantibus Subterraneis

479 **[479]** A subterranean body, as the name itself demonstrates, is classified into the animate and inanimate. Moreover, what is void of life is subdivided into that which spontaneously erupts from the earth under its own power, and that which is dug out of the earth. I have spoken about the former inanimate class in four books written about the nature of those things which flow from the earth: I have spoken about the latter in ten books written about the nature of fossils [which in the classic sense included minerals and their extraction from the earth, i.e., mining].

Now I will speak about subterranean creatures. Because the entire class of animate beings is actually based on four elements, and inasmuch as wet and dry material, i.e. water and earth, are available to be used, it is necessary that these two elements themselves be the physical basis of animate matter. From this fact, it follows, moreover, by a certain necessity of nature, that every animal is born either in the water or on land, dwells in both places and enjoys life. For instance, flying creatures, if they fly everywhere through the air, nevertheless construct nests on land, either in plants growing from the earth, or on buildings situated above it, and either the earth or the water supplies them with food. For instance, so that they might be named correctly, certain rare birds which are not very big, which have long wings, and which are distinguished by their somewhat pale yellow coloring, the sultan of Turkey wears on the highest part of his crown which is adorned with many precious gems, so that they live out the course of their lives perpetually in the air. He accommodates the female, which lays her eggs upon the curved back of the male, similarly the eggs, placed there, lie on her curved stomach, and she prevents the chicks, not yet alive, from touching the earth with feet, which are very small and hidden among their plumage. Nevertheless, they do not seem to be able to be nourished only in the air, nor are they able to develop fully, but they enjoy these things.

And truly even beasties [insects], which are named by the Greeks *purigonoi* [those generated by fire], because they are born in that terrestrial fire, lack neither earth nor water. Moreover, they are born, as Aristotle writes, in the very furnaces of Cyprus, in which copper ore is smelted for many days: and they are winged and a little larger than the great gadflies. In the fire, they wander and jump about, but they die as soon as they are separated from it.

Some of the animals, on the contrary, even if they are accustomed to hide, do not come up through cracks in the earth, nor through holes, nor caves: these are not among the number of subterranean creatures: some are active by night or during the day in subterranean caverns, some at a certain time of the year: both of these are considered subterranean animals on that very day or at that time of the year that they are under the earth's surface, and they can be referred to as such. Some generally hide in the earth in perpetual secrecy: these are subterranean and are always so, and are appropriately called "subterranean animals."

But in order that the matter might become clearer and better explained, I will begin a little higher. Since by nature all animals are aware of the change of the seasons, the majority, for the sake of avoiding cold or heat, either change their region or specific location, or they enter their respective dwellings — trees that are either hollow or carved out — or they descend into the earth. Moreover, of those which change their region [migrate], some, having left, never even return once, others return habitually: they are accustomed never to return as sharers of the property: humankind belong to this group. And as a matter of fact these establish their residence elsewhere not only for
480 the sake of avoiding cold or heat, **[480]** but they also move away from those regions which are poor and produce nothing to lands which are better and fertile, or if such a great number of people are born that the region cannot comfortably provide enough nourishment, some go elsewhere to live.

Certainly in this way, one area or part of the earth often lays aside the burden by which it is being crushed [over-population migration] onto another region. For these reasons, Scandia, the greatest of all the peninsulas, once sent out a great abundance of Goths together with their wives and children into Sarmatia and Dacia. To be sure, the floods of the sea drove out the Cymbri and the Teutoni from the farthest shores of Northern Gaul, where they had emigrated to from Germany. The inhabitants from Aenaria, whom Hiero, the tyrant of Syracuse, had sent there, were driven out by the same floods, as well as earthquakes, volcanic eruptions, and geysers of hot water. And generally for these reasons the conquered peoples who emigrated from these places were driven out and flung from their own homes and property, and in turn, they themselves even invaded foreign territories and overtook them. Those subjugated and overpowered by war were either slaves to their conquerors, or they were so defeated that the victors occupy that very region with a general condition of freedom.

In a similar way, animals that are lacking reason, especially birds, never gather to return to lands that are foreign from those where they were born and became accustomed to live. This occurs only very rarely. In this way, six years ago, the locust plague, devastating to grass, legumes, grain, and woody plants, which they destroy, in a flock descended upon the city of Pannonia, in Dacia, upon the ancient region of the Marcomannian people, and upon Lygia, just as formerly they often descended from Africa on the other European countries. In fact, sometimes when a single man disappears in remote regions, and does not ever come back from there, in the same way, one single animal: in this way, nearly 20 years ago an animal was captured in Noricus that was covered in the shaggy hair of a dog: whose front feet, like on Ethiopian goblets, were similar to human hands and its back feet to human feet. And two animals were caught in the Slavic forests in the time of Albertus Magnus, one male and one female, whose front feet did indeed resemble human hands and whose back feet resembled human feet. Truly Albertus himself thought them to belong to the ape family. And Pliny recorded from recollection the Egyptian ibis, seen in the Alps by the Prefect Marcus Ignatius Calvinus. We also know that the Northusian eagle died in Thuringia, since it had grown old there. Even in this year, which is the 28th year of the rule of Charles the Fifth, a certain butcher from Dyncelspyhelensis, having subdued an eagle, killed it and brought it as a gift to the Senate. On the day before Epiphany, the eagle flew at the man seated on his horse near the town of Rotelis with so violent a force that he was in danger of losing his life. In the same way, it even seems true that some fish, when they leave the sea behind one time, enter into streams, which flow through remote regions, and never return to the same sea.

Till now I have spoken about the kinds of animals that do not return to the region from which they have left. Now I will talk about those which are accustomed to return: these are also the same animals, and they generally move out of a region where they live for the same reason: most definitely to avoid heat and cold. And indeed, in the summer they stay in cold places and in the winter in warm. As a matter of fact, humans who pay attention to their good health, so that they might protect themselves from the heat, are in summer quarters [i.e., their airy villas in the countryside or on the coast], and in order to protect themselves from the cold, are in winter quarters: which was the custom among the first Romans. And even kings and rulers of many citizens went away into other lands in the summer, to others in the winter. For the kings of the Persians once spent the winter season in Babylon, the spring in Sufi, and the summer in Ekbatana. In the same way, **[481]** flying animals and aquatic animals change their region and withdraw. Of these animals, some are used to seeking cold in the summer and heat in the winter in those very regions and lands in which they are accustomed to spend their lives. Others do so in remote and far-off places. And generally they fly, swim, and walk in order to inhabit these places in which the weather is so temperate that it produces or furnishes sustenance. The earth, when it grows numb with cold or it dries up from heat, withdraws from them the ability to produce food: water is not available to them when it has frozen. 481

In fact, certain birds generally abide in the woods during hot weather and in barns and outbuildings during wintry weather: for example, the magpie, the crow, and the sickly yellow bird which the Greeks call ***iktorou*** [*ixtegog*] [identity uncertain], the Latin-speakers call the galgulum [an oriole {or small bird}]. Certain birds spend time in the woods during the summer, they migrate to neighboring sunny places in the winter, having sought out recesses in the mountains: for example, vultures, kites, starlings, thrushes, blackbirds, wood-pigeons, and hoopoes. Aquatic creatures as well as birds gather during the wintry seasons at lakes and rivers situated in southern regions, which do not freeze in the cold, or they gather in some part of the rivers that does not freeze up entirely: for example, herons, gulls, water cormorants, pelicans, coots, savage ducks, and teals. Some birds scatter as if from one end of the earth to the other: for example cranes. And indeed, as Aristotle explains, they set out from the plains of Scythia to the higher marshes in Egypt, from where the Nile flows forth. Swans, storks, and wild geese go even farther. However, a few birds remain in the woods during the winter, such as grouses and hazel-hens: very few of the many birds remain in the fields, but among the number of these are partridges.

Likewise, some fish, in order to avoid the heat of the sun, during the summer go from the shores to deeper water, and on the other hand, so that they might be able to seek mild warmth, during the following season, they emerge from the deep water in which they had immersed themselves and return to the shore: for example, dolphins. Others move from one sea into another, such as tunny-fish, [which] during the winter season goes from the Black Sea to the Great Sea [Mediterranean], and likewise, in the spring from the Great Sea to the Black Sea. Others, in the same season go to the rivers, such as salmon, tuna, and sturgeon.

And these cannot be called subterranean animals: just as any others that do not enter into caves in the earth cannot be so called, even if they are concealed and lie hidden during the winter months for the sake of avoiding the cold, or during the summer for the sake of avoiding the heat. Such creatures include humans who primarily inhabit either cold or hot regions: for those who inhabit the former hide in their homes during the winter season, and those who inhabit the latter hide in their homes during hot weather. For indeed, among the quadrupeds, hedgehogs hide themselves in hollow trees, in which they collected apples during autumn. Similarly, dormice and mice from the Black Sea, and certain snakes hide themselves in hollow trees, but they themselves go into crevices in the rock for the majority of the time, as I will explain later.

Even certain roaches and wood-lice conceal themselves in the cracks of walls or hiding places in houses. Likewise ants are buried in ant-hills, in which piles they expend much of their work and labor during the spring and summer. In the same way, domestic bees enter their hives, wild bees enter either hollows of trees, holes in the earth, or into old walls. Likewise wild hornets enter crevices, just as they enter certain nests in trees: wasps enter nests in trees or houses, which they constructed in the summer. Similarly, in the winter a few birds do not hide in hollow trees: for example, the cuckoo, the woodpecker, a raven whose head is stained with a red mark, and who is called by the Greeks *purrokorax* [a crow with a red beak] for this very reason, and the hoopoe. But swallows, as native as country peasants, withdraw to nearby places that have more mild climates. These birds, if they lack milder places, bury themselves in narrow, confined places in the mountains, in which starlings, wood-pigeons, turtle-doves, blackbirds, thrushes, crested larks, and
482 hoopoes are also sometimes accustomed to hide. Similarly, they lie hidden either **[482]** in trees or in the mountains, and for this reason in the spring, they are accustomed to be visible without feathers.

I have said a sufficient amount, and perhaps even more than the established subject requires, concerning those animals which do not enter either cracks or holes in the earth, or caves for the sake of avoiding cold or heat. Nevertheless these things which have been said adhere so closely in nature with the things which follow, that once separated, they are scarcely able to be properly explained. Therefore, there are three classes of those animals about which I have undertaken, by the grace of the almighty, the labor of writing this work. For indeed, certain animals enter caves in the earth either at night or during the day, and they hide or sleep in these caves. But a good many animals and even all of them come out during the winter to find food. Some animals, at a certain time of the year, enter subterranean caves, and spend [hibernate] several months overwhelmed by deep sleep. Certain animals generally hide in the earth in perpetual secrecy. Among those in the first class are not only terrestrial animals, but also birds: however, I will pursue a discussion of the earthly creatures first.

Among the number of creatures who descend into caves are, indeed, humans who, for this very reason, are called troglodites [from Troglodytae, a race of people centered around the Sudan and said to be cave-dwellers]. Some of these go into these caves for the sake of avoiding the heat, like the African and Syrian peoples who live near the Red Sea. Others go into caves for the sake of avoiding the cold, like those who inhabit the plateau in Asia behind Mt. Caucasus, which is situated near the northern territories, and the Scythian peoples, and the wild men, who are hostile to sailors at night and live in the Scricfinnian region of Scandia. They drive the sailors away with flaming funeral pyres. And indeed, in the greater part of Armenia, as the illustrious author Xenophon writes, the homes are subterranean, of which the narrow doorways are in the form of wells, the portion below the earth is broad, the trench-like approaches are made by mules, and men descend into them by stairs. In fact, on the island of Tenedos, fisherman nowadays use caves in the cliff faces as homes, just as the robber, Cacus, once used a cave between the Aventine mountain and Salinas [a district of Rome]. He covered his fearful face and made it inaccessible to the rays of the sun: just as the Sibyl [a prophetic female] in that Cumaean grotto near Lake Avernum, as distinguished for her work as a muse as she was respected for her predictions. And Circe, a woman famous for her spells, lived *en spessi glaphuroisi* [in hollow grottoes], as Homer tells. Indeed, among the Seduni [a Gallic tribe] in the region of Sittensis near the Bremisa district, the entire monastery was built from the edge of the cut-out cliff face with wooden beams and any tree trunks. In that place there is a temple, an inner shrine, a bedroom, a kitchen, and a wine cellar. Similarly, in the high mountains, subterranean citadels are in evidence: like that one in the Alps called Cavolum, to which neither cavalry nor footsoldiers are able to ascend, but when men ascend there they bring along to that place everything which is necessary for survival. Another is on a steep cliff in Sicily, not far off from Mt. Eryx, joined by a little bridge with Cape Drepanum, by which land it can be approached. A third is in Saxony between Blankenburg and Halberstadt. Yet another is in Thuringia between Weimar and Blankenhain, near the Mellingen plain: the ancient name of the place in Saxony is Reinestein, while the name of the one in Thuringia is Pufhard, and it is four miles from Weimar. Each of these is now deserted and empty of inhabitants: each has cut into the rock a hypocaustic underground heating system, chambers, steps, stables, stalls, doors, and windows. In fact, the place in Saxony even has a temple, which the inhabitants built above the watchtower, which structure alone was built up to the horizon. This temple is in the form of a tortoise, and is marked with a round funerary monument in the middle, all the rest are square. The Saxonian mountain itself is steep on all sides, except the one by which it can be ascended. On the plateau of this mountain a lofty hill rises gradually, which looks at the plateau from that side, and is surrounded by a deep enough and broad enough ditch. From this hill that citadel was constructed with cut rock that is sandy and partly red. **[483]** The citadel has many large windows, and in fact, there 483
are subterranean cellars at the foot of the mountain itself along with the horse stables. Each citadel has created a familiar riddle for the Saxons and the Toringi:

> Tell in which lands a citadel is built on a high mountain,
> where a thousand sheep can wander through the building.

Also, Hoenstein, which is a citadel in Mycenea, on the other side of Albis, has stables for the horses cut into the rock. And the Praenestian subterranean trenches are glorified in literature: Caius Marius was besieged in one of these, and he perished there. And moreover, it is evident from the writings of the comic poets that Greek women who made a living publicly as prostitutes lived in subterranean apartments: *chamaitupeia* [brothels] are named for these women. And the translator from Terentium thinks a gluttonous eating house is called *apo gas* [out of the earth], because it is in the earth. There were even such cellars in Rome, and indeed they were frequently within the Circus Maximus, where it extended for the mock sea-battles into the villages of Subaranus, Summaenianus, and Thuscus. In fact, in Rome, there were subterranean altars to Dis [Pluto] and a subterranean temple to Consi [an ancient Italian god]. And we gathered to dig out subterranean ditches for the ancient underworld gods and caverns for the nymphs. And, in fact, in certain maritime cities in Germany, just as in Prussian Danzig and in Saxon Lubec, a good portion of the population lives underground in movable sheds, above which magnificent homes were built, which are inhabited by the lords.

In the same way rabbits, foxes, beavers, otters, badgers, and perhaps certain other creatures enter burrows [or dens] but they leave to find food even during the winter. And indeed the rabbit [**Cuniculus**] digs many holes and drives the earthly rabbits into the hills: from this behavior the rabbit gets its name. It comes out in the morning and in the evening, but it generally remains hidden the rest of the time. Moreover, it covers some holes with dirt so that they can't be found by predators. But the ferret and certain small dogs, whose noses are keen at investigating, [when] sent into the holes and against the rabbit, find it, and [hunters then] pour boiling liquid in on it: they force the rabbit, [which is] put to flight and driven out of its hole, into the snares, by which it is captured. Moreover, there is not [just] one single color in rabbits: in fact, a rabbit is either dark, like ashes, or in a certain measure similar to a hare, or it is spotted, for example: they are white, speckled with either black or yellow spots.

The fox [**Vulpes**], however, first and foremost clever at trickery, does not dig holes itself as much as it seizes those burrows hollowed out by other animals. And it drives off the badger from its stolen hole with its foul stench, because it stains its mouth with manure. It hunts hares, rabbits, mice, hens, birds, and little fish. In fact, it does everything craftily. As a matter of fact, it often seizes unprotected hares and rabbits, while pretending that it wants to play with them, just as cats do with mice, and it is accustomed to lie in ambush. At night, in secret, having entered the chicken coop, it seizes hens and carries them away. It kills and devours birds which approach it while it deceitfully pretends to be dead. Lying on its back on the ground, it wards off the attack of an eagle with its feet until it can tear apart the captured bird. The tail, which for this animal nature made large and dense with shaggy hair, lowered down from the banks into a river, catches little fish swimming in that river. And when it pulls itself up a little bit from the bank, vibrating its tail violently, it shakes off the captured fish onto the ground and devours them. Furthermore, it approaches a wasp's nest by walking toward it backwards, because it fears that it will be stung by them. And if it sends [sticks] its tail into the nest, it wards off the wasps. Soon, drawing out the tail, crowded with these very insects, the fox dashes it against a nearby rock, or tree, or house wall, or garden wall. In this way, with all of the wasps crushed and killed, it empties and destroys the nest. Likewise, a dog, led this way and that by its own mouth, when it pursues its tail, is eluded by it. But the
484 hedgehog [**Erinaceus**], which because **[484]** of fear rolls up in a ball, so that it is able to defend itself on all sides with its spines, is urinated upon by a fox, and in this way suffocates it. And indeed, on account of the urine flowing into its mouth, it has no power to draw breath. In fact, this

is the way of the fox, which is the size of an average dog. Moreover, it is often a red color, yet the coat is whiter in the forequarters. Rarely, it is pure white, even more rarely, pure black.

Furthermore, the beaver [**Fiber: Castor**] and the otter [**Lutra**] come out of burrows in river banks, in which they hide themselves, and immerse themselves in rivers, and capture fish, on which they feed. But they also eat the fruit and the bark of trees. Moreover, the otter is named from washing [the verb *luo* means to wash]. And indeed, when it frequently bathes in the waters for the sake of catching fish, often it immerses itself entirely in the depths of the waters. And Varro thinks that this name [the otter] comes from the Greeks, and he thinks that the otter was therefore named for a ransom [*lytra*], because it is said to cut down the branches of trees into the water, and to destroy them. Moreover, it can generally swim underwater and travel quickly for as great a distance as a taut bow is able to loose an arrow before rising up again into the air to draw breath. If it cannot breathe this air, just like other animals that walk on land, it suffocates. Its body is broader and longer than that of a cat, its feet short and its teeth sharp. It is different from the beaver with respect to its tail, its rear feet, and its hair. For the otter has a tail which is long and similar to that of the other quadrupeds: yet the beaver has a tail which is covered with fishy scales, exceedingly thick, about one palm wide, and ¾ of a palm long. If it lies on a slope, it sends down its tail and hind feet into the river when it is not frozen from the cold. When it swims, it is accustomed to move its tail as if it were rowing. Moreover, all of the feet of an otter are similar to those of dogs: the front legs of a beaver are like those of a dog, and the rear are like those of a goose. For in fact, there are certain membranes lying between the toes. In this way, the latter legs are more designed and suited for swimming and the former for walking, for it lives both in the water and on land. Also, the hair of the beaver is white mingled with gray and uneven in length, for everywhere there are hairs that are twice as long as the shorter hairs. But the dusky-colored coat of the otter deviates in only a small measure from that of a chestnut tree, and is short and uniform. And certainly the hair of each is shining and soft, hence they are accustomed to adorn the edges of garments made for nobles from their pelts with cut hairs of each of these animals. Although the coat of an otter is far better than that of a beaver, nevertheless, the coats of beavers differ a lot in color among themselves, for some more than others are made up less of black, some of red. And indeed, the more black ones are far better than the rest: they have less black on the middle of the body, and they are somewhat red on their lowest parts.

The beaver, however, is first and foremost thoughtful and ingenious: for indeed, with the shrubs and small trees cut down with its teeth as if by a sword, it constructs certain small dwellings facing holes in river banks, and into these it constructs two or three steps, as if into certain vaulted rooms, so that when the rising water of the river overflows the banks, it can ascend into its home, and it can climb out when the abating water remains level. And indeed, now when it generally cuts down a tree, as often as it makes a blow, it sits down looking at whether the tree is about to fall. For the beaver fears lest, if the tree should fall from that blow, the defenseless animal, unable to run away from the place before it fell, should be crushed by it. Certainly it is no less steadfast in its lifestyle than it is clever: for first it chooses which tree on the banks should be cut down, and it does not change its mind, even if it cannot cut it into pieces for a long space of time. This animal sends out a sound like that of an infant: moreover, we hunt it not only because of the tail, which we eat and the hide, which we wear, but also because of its testicles, which we use as medicine, preferably those belonging to beavers from the Black Sea, since they have the greatest potency. These testicles I say that they call castor [an aromatic secretion from the beaver that is used medicinally]. For the Greeks call the beaver *kasora* [a beaver]. But the beaver was named by the author Varro from the outer right and left banks of a river, where it is generally accustomed to be seen, **[485]** for the ancients called the beaver an outsider. 485

But the badger [**Meles**] goes out of burrows and wanders in the woods no differently than the wolf, the wolverine, the wild boar, the deer, the antelope, the reindeer, the elk, the wide-horned stag, the roe-deer, the ibex, the mountain goat, the gazelle, and many others. In fact, the former animals sleep in the woods, yet the latter sleep on lofty rocks and cliffs in the mountains. Moreover, the badger greedily eats honey, from which it gets this name. It is the size of a fox or an ordinary dog, but for the most part presents the appearance of a dog. For there are two classes of badger. One has toes like a dog, which they call canine: the other has cloven feet, like pigs, which therefore they call pig-like. Moreover, the legs of all badgers are short, the back is broad, the skin is thick, and by stretching it out, puffed up in fear, I use the words of Pliny, they defend themselves against the blows of men and the bites of dogs, but nevertheless, if ever they fight with dogs, they bite viciously. They are covered in rough, shaggy hair, which is either white or black, and the back especially has a large amount of black hair, while the rest of the body has white, with the exception of the head, which by turns is decorated with stripes of black and white drawn from the highest part of the head to the jaws. Moreover, badgers are not coarse, yet they are fat. Their fat, anointed or poured on with garlic, calms the pains of the kidneys. From this animal, collars are made with their hides, which are called *melia* [collars] by Varro for this reason.

Furthermore, kingfishers [**Halycon**] build nests on the banks of rivers and lakes: and it was unknown to Aristotle that they climb in streams, but they are not hidden in the winter. This bird is not much larger than a sparrow. Moreover, since the whole body of the marine kingfisher is distinguished by mixed colors: blue, green and dark red, to such a degree that neither the neck nor the wings are lacking any of these and it has a long, thin, greenish beak: the chest of either the river-dwelling species or the bank-dwelling species is dark red, the neck and back are blue mixed with green, the wings are dusky-colored, and the beak, like the feet, is ash-colored. It eats fish and worms.

Likewise, the ptarmigan [**Lagopus**] builds nests and sleeps in caves of the lofty Alps near the ice field, which is never totally melted by the heat of the summer sun, and is even extended in other seasons of the year by rainfall. It takes its name from its feet, which are covered with shaggy white fur, like a hare, as opposed to feathers. It is the size of a pigeon. Its color is white in the winter, and ashy mixed with white in the summer. It does not fly far off, but stays in the Alps. It does not survive in captivity, and even less likely is it to be tamed. The flesh of this bird is good for a healthy palate, and health-giving for a sick one.

But the birds, whose eyes are weak during the day, are keen and sharp by night: they are accustomed to hide during the day, to fly from their hiding places by night, and to come out to find food: these, therefore they call nocturnal. Of this sort are the bat [**Vespertilio**], the horned owl [**Bubo**], the screech owl [**Ulula**], the little owl [**Noctua**], and the night raven [**Corvus nocturnus**]. In fact, the latter hide not only in dark places of the mountains and in caves in the cliffs, but even in hollow trees, in deserted buildings, and under the roofs of magnificent homes and temples and towers, which men rarely climb. Moreover, the bat hunts gnats and flies: it consumes ham, and other pig meat hung from the rafters. Other nocturnal birds pursue mice, swallows, birds, beetles, bees, wasps, and hornets. But the horned owl [**Bubo**], however, snatches young hares and rabbits. It seems to me that these greatest of all the nocturnal birds got its name from the sound, indeed the deep groan, which they emit. It has a huge head: the head is the size of a goose's, yet it is short and blunt and varied in color. The beak is curved, the talons are hooked, and the eyes are massive. A screech owl [**Ulula**] is not much different than this bird, except smaller. Likewise it derives this name from its shrieking call.

486 **[486]** Little owls [**Noctua**] are related to these two kinds, but they differ in their call. For indeed, they do not shriek, but they produce a sound which Aristophanes called *kikkabau* (a cry in

imitation of an owl's call). There are four kinds of these owls. One, whose feathers stand out especially over the ears, and which is the greatest of the four, is called the little horned owl. The second, with outstanding white plumage on its throat and stomach, is distinguished as well for its alternating white and yellow spots. The third is small, and for this reason, as follows, bird-catchers hunt these birds. The fourth is smaller than the third, which dwells in cliffs and rock faces. This one, just as the previous kind, is marked with alternating ash-colored and white spots. In contrast, the nycticorax (night raven), which is a nocturnal raven, is black, like ravens of another class, but it is smaller and more common than those.

But the bat [**Vespertilio**], which gets its name from its habit of flying out in the evening [vesper], is to a certain extent similar to a mouse, hence the excellent Varro wrote: "I was made a bat, and I do not fit among mice or birds." For it has wings and flies, so it does not fit among mice, but it gives birth to living offspring, not eggs, for which reason it does not fit in by nature with birds, and it nourishes its young with milk from its teats, while birds seek out food from all around, which they put into the mouths of their chicks. In addition, bats have teeth, which birds lack. Moreover, the bat has a similar head to a mouse or a dog: generally they have two ears, rarely four, and serrated teeth. Their bodies are covered with a coat of tawny hair, yet their snout is black, as well as their ears. Bats have two wings, which, like those of a dragon or a flying fish, are not known for their feathers, but for their membranes and are also black. On each side, in fact, the wing has a finger, on which there is a talon. The bat has a broad tail, which is membrane-like in the same way as the wings, on which there are two feet, each of which has five toes armed with curved claws, with which it hangs from the walls and cracks of caverns. For indeed, it either hangs, or flies, or sleeps. Because, in fact, the feet do not come directly from the body, but from the tail, it is said that it only has one hip. It does not produce a sharp sound like a mouse, but it almost yips like a puppy. Moreover, according to Pliny, it flies around grasping its two offspring and it carries them along with it. It lives for several days with its tail joined to its wings. In fact, in the same way, the Troglodytae [the cave-dwelling people], who live in Africa, during the day, especially at midday, hide in their caves.

This is enough concerning creatures of the first class, which hide or sleep in caves in the earth either during the day or at night. I proceed to the animals of the second class, which, as I have said, enter into subterranean dens at a certain time of the year, and in these dens, pressed by heavy sleep they spend [hibernate for] several months without food, as if dead, and they hide continuously till the end of the season, when, awoken from the ground by the warmth of spring, they come to life again, and they remember food, which they had forgotten to consume for such a long time. Although I have already spoken about these animals, there are even some, as there are certain animals of every class, in the number of the following creatures, as I will explain at this time.

There are, for instance, some earthly creatures, or birds, or aquatic animals, whose lives are spent equally on earth and in the water: but at this time I will first explain the earthly creatures. Along these lines, many quadrupeds bury themselves in burrows during the season of winter or summer. And indeed, Alpine mice [**Mus alpinus**] enter burrows during the autumn, in which they are accustomed to sleep during the summer heat. For in these burrows, they build up nests from hay, straw, and twigs, in which, rolled up like hedgehogs, they hide themselves and sleep for the whole winter up till spring. In one cave there are often seven, or nine, or 11 or 13 mice. Indeed, they have marvelous skill and cleverness when they gather hay and scraps. In fact, one lies prostrate on its back on the ground with all of its feet stiff, while on its body, as if on **[487]** a certain 487
wagon, the rest pile those things which they gathered, and thus laden, with its tail seized upon by the others' teeth, they drag it to their hole and in the same way they carry it in. It happens in this way, with the result that during this time of the year, they seem to have a raw back. And thus, after

they have made a nest in their burrow, they barricade and stop up the entrance itself and the mouth of the burrow with twigs and earth so that they might be able to be safe from the force of the winds, from the rain, and from the cold. Moreover, they sleep so soundly and heavily that having been dug out and removed from the burrow, they would not awaken before they grew warm from being exposed to the sun or placed near a fire. This mouse derives its name from the Alps, in which it is born. Its color is either dusky, ashy, or red. It is about the size of a hare but it has the appearance and shape of a mouse, for which [reason] it is called a mouse. But, however, it has ears that are stubby as if they were cut short: its front teeth are long and sharp: it has a long tail more than two palms [about 20 cm] long, and feet that are short and covered on top with shaggy hair. It has toes on its feet that are similar to those of a bear, and long claws, with which it digs deep in the ground. It is not accustomed to walk with its back feet alongside one another and turned backward and it sometimes walks on two feet. If food is given to this animal, it grasps it in its front paws, like a squirrel: indeed, just like a squirrel and an erect ape, it always sits on its haunches until it has consumed the food. It does not feed on fruit in this way, but specifically bread, meat, fish, gravy and condiments. Truly it feeds most eagerly on milk, butter and cheese, and, when it consumes these, it emits a sound just like a piglet by sucking with its mouth. It sleeps a lot, but when it is awake, it is always getting something necessary for its bed: straw, hay, strips of linen, and sheer fabric. It fills its mouth so full with these things that it can take up nothing further: it seizes the rest with its paws and drags it. When provoked, the mouse blazes with anger and bites savagely. If ever the Alpine mice [**Mus alpinus**] play amongst themselves like puppies, they make a lot of noise. When they leave the cave, wandering over the mountain to find food, someone of the mice remains next to the entrance of the cave, and is able to keep watch as diligently and as distantly as possible. When this mouse sees a human or a herd of cattle or a wild animal, it makes noise without delay. At this sound, all of the mice from all around run together to the cave. Moreover, the call of these mice is similar to the high-pitched shepherd's pipe and hurts the ears. With this call, they indicate a change in the environment and that enemies are approaching. They have a very fatty back: the other parts of the body are leaner than it, yet it is not possible to say whether it is truly made up of more fat or meat. But as the meat in cows is in the udder [area], among these mice it is somewhere in the middle. This is useful for women after childbirth and for those who are in labor: in fact, for these the fat of mice is beneficial. It is also a good remedy for insomnia.

And similarly, dormice [**Glis**] hide during the winter not only in hollow trees, about which matter I have spoken previously, but also in holes in the earth. Indeed, Aristotle calls the dormouse *eleion*, and it is ash-colored as Albertus [Magnus] writes, with the exception of the stomach, which is white. The dormouse differs very little from the little creature which some Greeks called *kampsiouron* [bent-tailed one] for this reason: because it turns and bends its tail up in the air. In fact, others called it *skiouron* [shadowy-tailed one] because its tail is covered and abounding with shaggy hairs, just as one is accustomed to cast a shadow over their body with a fan. Still others call it the *mus skiourou* [shadow-tailed mouse] because it also bears a certain similarity to the appearance of a mouse.

This is just like the case with the Fennican squirrel [sciurus Fennicus], which does not differ in its tail, nor its shape and features of its whole body, nor in its size, nor in its behavior, but only in its color from our squirrel, for it is ash-colored mixed with white, while our squirrels are either red or black. And yet in that part of Sarmatia, which today we call Polonia, the red color is found mixed with gray on squirrels. Furthermore, for both types of squirrels, [and] this applies as much to Fennican squirrels as to ours, the two last teeth are long: when each class of animal walks, it
488 drags its tail behind it: when it eats, it takes up the food **[488]** in its front paws, which it uses, as mice do, in the place of hands. It stands on its hind feet and its haunches. In fact, it eats beech nuts,

chestnuts, Avellian nuts, apples, and similar fruit. In the winter, it eats the cones of fir, spruce, pine, and other trees. Every spring they give birth, and if anyone should put their hand into the nest, they transfer their young into another one, for they make several nests. The feeble babies of both kinds of squirrel eat meat, and because it is disturbing to them to taste a certain unpleasant flavor, they rarely eat sumptuous things. In addition, both kinds dwell in trees, yet they do not bury themselves during the winter. But when they hide like dormice during the winter, sleep takes the place of food and they grow fat during this time of the year. Therefore Martial wrote correctly concerning the dormouse:

> The whole winter is slept away by me, and I grow fatter at that
> time of the year, in which nothing but sleep nourishes me.

Moreover, the meat of this animal is sweet.

In fact, although dormice live in forests, so that Varro might not make these complaints without cause about the scarcity of these creatures in Fundanius, concerning these admirable creatures: "There is no dormouse in my forest, yet the ancestors had dormice." Which sort they ought to be Varro described in the third book of *De re rustica* [*On country life*]. And today in certain forested locations, the inhabitants dig into the earth so that dormice might be able to live in burrows in it and whenever they wish to seize them, they can use them for food. In fact, among the Romans, Fulvius Hirpinus created enclosures for dormice in large earthenware vessels, according to the writings Pliny left behind.

On the other hand, the Black Sea mouse [**Mus ponticus**], which today they call Hermela, hides alone during the winter in hollow trees, as I described before. It is entirely white like snow, except for the long tail, for half of it and especially the tip are jet black. This animal is the size of a squirrel. It attacks mice and birds, which it eats. Its pelt is among the number of valuable things, just like that of the mouse which they call Lassician. It is white mixed with ash-color and it is not two inches wider than that mouse.

But the gopher [**Mus noricus**], which they call the Citellus [ground squirrel], lives in caves in the earth. Its body, just like that of the native weasel, is long and thin, its tail exceedingly short: the color of its hair, like the hair of certain rabbits, is like ash, but even darker. Just like the mole, it lacks ears, but like a bird, does not lack ear holes in which it receives sound. It has teeth similar to the teeth of a mouse. Indeed, from the coat of this animal, although it is not valuable, clothes are often made.

The Pannonican mouse [**Mus pannonicus**] also goes into burrows in the earth: its color is somewhat green, its appearance like a weasel, its size like a mouse. And the shrew [**Sorex**] buries itself for the winter months in the earth, into which the cavern descends almost to a depth of three feet. Dug out and exposed to the sun, like other animals that sleep during the whole winter, it wakes itself up by moving very slowly. It measures three-quarters of a foot long: its color is reddish in the summer, mixed with dusky color, in the autumn it is gray. Its ears, as Pliny writes, are shaggy [hairy]: the base of its tail, at the lowest part like that of a fish: for it is not totally covered and full of hair, like a squirrel, but in fact, the hairs on its ears are very small. This mouse climbs trees in the forest, like the dormouse and the Pontican mouse and the squirrel. The female eats the fruit of pear trees and Abellian [hazel] nuts, therefore among the Germans she takes her name from the hazel tree. But another mouse of the forest is shorter than the shrew, and it measures half a foot [semipedalis: approx. 12.5 cm]. The color on the back and flanks is a gray-mouse-color, the stomach is white. It digs into the earth at the base of shrubs to a depth of two feet [duum pedũ: approx. 50 cm] and a length of four feet [pedes quatuor: approx. 100 cm], and in the bottom of the burrow the whole group gathers a portion of acorns and the fruit of cherry and plum trees, and other fruits,

but especially Abellian nuts, since these are the best. The animal derives its name from that very
489 kind of nut. **[489]** It generally makes its nest in the middle of the excavation in the form of a pile of leaves from trees, so that if water ever falls in drops on the earth, it falls outside, and the Abellian mouse sleeps dry inside its nest. Moreover, on the other side of the excavation it has a hole, by which it is able to exit the nest when it digs out Abellian nuts

On the other hand the shrew mouse [**Mus araneus**], just like the rest of the domestic mice, does not hide in the earth. This mouse, for the following reason, because it instills venom with its bite, like a spider, acquired its name among the Latin speakers. Among the Greeks, however, who call it *mugalein* [shrew-mouse or field mouse], with respect to its size, as Aetius, who describes it briefly, said, it is equal to a mouse, but in color it is similar to a weasel. More specifically, the color is reddish mixed with a dusky color, except on the stomach, which is a mottled whitish-gray color: it has a long pointed snout. On each jaw, the teeth end in double points and for this reason, animals receive quadruple wounds from the bite of this creature. It has beady black eyes and a short tail, on which the hair is very short: in warm climates its bite is often pestilential, while in cold areas it is not. And moreover, when the shrew mouse is wounded or dismembered, it heals itself by placing its own poison on the wound. Cats capture and kill this animal, but shrinking from its venom, they do not bite it, just as they do not bite the rat. In fact, although the rat does not hide during the winter, nevertheless it enters underground burrows in the Ioachimican valley from its most recent home and it dwells in these burrows. Otherwise, especially during the cold season it is accustomed to wander in our homes. It nearly rivals and is equal in size to the mass of the body of the smallest weasel. Its coat is blackish, its tail is long, extremely thin, and totally bare of fur.

But several types of mustellids hide in the earth, and there are many of them. In fact, there is the domestic weasel [**Mustela**], which the Greeks call *galeein*, and the Germans call *viselam* [*Wiesel*] because of the sound it makes. It is generally reddish yellow on its back and flanks, rarely yellow. It is always white on its throat and stomach, but in fact, it is rarely found totally white.* It has a body that is slender and long, a short tail, short front teeth, not long like a mouse, and it is eager to reproduce. Because it fears danger for its recently born young from humans and several other animals, it transfers its offspring every day to another place by grasping them in its mouth. It hunts mice, and it fights with snakes, and so that it might be safe from the snake's venom, it eats rue first. It bites the udders of cows, and when they are first swollen, they are healed by being rubbed with the hide of a weasel. This weasel, if it lives in our house, and if it has its own caves does not bury itself for a long time and very often: if it lives in the countryside, it hides in holes during the cold season.

The Germans call the second class of weasels *iltiss* [polecat, eds.] from the Greek word *iktis* [yellow-breasted marten, eds.], which learned people call the forest-dwelling weasel. Moreover, this creature lives in hollows in river banks, where it eats fish captured in the manner of an otter or a beaver, and it also dwells in the woods, where it catches birds, and in homes, where it eats hens. Therefore Pliny says that it is domestic. It squeezes the blood from these birds, but lest the prey be able to protest, first it removes their heads by biting. And it also deprives them of their eggs, which it is accustomed to steal, and to gather many of into one pile. The domestic weasel is somewhat larger, shorter, and thicker than the forest-dwelling weasel, which is called the marten. It has hair that is uneven in length and not of one color. In fact, the short hairs are yellowish, the long hairs black. Thus, those black hairs stand out from many parts of the body, with the result that they seem to be marked with black spots. But yet, the hair around the mouth is white. When the animal is heavily provoked it smells badly. On account of this, the hide is worthless to us, and they are accustomed to call the hide of this type of marten extremely foul-smelling.

---

* [literal translation] "and in fact, it is not never found totally white, although rarely" in which Agricula uses the the double negative. [Eds.]

The third class of forest-dwelling weasel sleeps in cracks and caverns in rocks. This animal is called *martes* by Martial, *martarus* [*Marder*] by the Germans. This line of Martial is in the tenth book of Epigrams on Mother Nature:**[490]** "When the marten is caught, the proud hunter arrives." 490 It is about the size of a cat, but a little longer. In fact, it has shorter legs, and subsequently shorter claws. Its entire body is covered with mixed black and tawny hair, except for its throat, which is white. Similarly to the preceding kind, this weasel enters homes and kills hens, and squeezes out their blood and deprives them of their eggs.

The fourth class of weasel is also forest-dwelling, it lives its life in trees, but it is also called by the name of marten. This weasel only leaves the forest rarely and contrary to its usual behavior, and it differs in this respect from the type of weasel just mentioned most recently. In addition, it differs in that its throat is saffron-colored and the hair on the rest of its body is a darker yellow. They say that there are two classes of this animal: one which lives in beech trees in the woods, another which lives in firs and which is much prettier to look at.

The fifth class of weasels is the handsomest and noblest of all which the Germans call *zobelam* [*Zobel*] (sable-colored). It spends its time in the woods, like the martens about which I have already spoken, it is a little smaller, yet it is entirely a dark tawny yellow color except for the throat which has gray on it. Weasels of the latter three classes stand out much more than all the rest in the degree to which some white hairs are mixed with the yellow ones. Moreover, sable-colored pelts are worth more than cloth woven with gold. For I have heard that a number as great as forty of the best pelts are accustomed to be bound together in one little package and sold together, and they sell for more than a thousand gold coins. Moreover, the entire race of weasels, when stirred by anger, smell like something horrible, but especially that animal which the Germans call *Iltiss* [polecat, eds.]. In addition, the entire filth of the weasel is redolent of musk.

On the other hand, the mink, which also lives in the woods, is the same size as a marten, and it has short hair that is a uniform length and it is about the same color as the hair of an otter, but the pelts of minks are far better than the pelts of otters. And these especially stand out if white hairs are mixed with the rest. This animal is chiefly found in the vast, dense forests which are between Sueva and Vistula. Although it is true that all weasels neither hide during the winter months nor go into the ground, nevertheless I have portrayed the unique features, because as an observer, this would be useful for the future study of natural history.

But the ferret which drives rabbits from their holes is a little larger than the domestic weasel. Its color is generally that of a boxwood tree mixed with white. This animal is bold and ferocious, and hostile to almost the entire animal kingdom: it is unfriendly by nature and drinks the blood of those animals that bite it, but it hardly ever eats the flesh.

The hamster is nearly as ferocious as a destroyer of fields and an enemy of Ceres, which some call Cricetum [a hamster]. The inhabitants of Palestine once called it an *arktomun* [bear-mouse, eds.] in Greek and for the reason that it belongs to both the class of mice and that of bears, since it stands upright on its rear legs, on account of which it is seen to have a black stomach. It seems angry and caustic to such a degree that if an unprotected horseman were to pursue it, it is accustomed to leap up and seize on the face of the horse, and if someone were to capture it, it is accustomed to hold on by biting. It lives in caves in the earth, not unlike rabbits, but the caves are narrower and for this reason, skin covers its haunches on both sides, it is bare of fur. It appears a little larger than the domestic weasel: it has exceedingly short legs. The color of the hair on its back is about the same as that of a hare: on its stomach the hair is black and on its sides it is reddish. Moreover, each side is marked by three white spots. The highest part of the head, like the neck, has

the same color as the back: the temples are red, and the throat is white. The tail, which is three inches long from side to side, is the same color as the tail of a hare. Moreover, the hairs cling to the skin, so that it is very difficult to pluck them from it. But the skin, on the other hand, is very easi-
491 ly separated from the meat, and the hairs are removed from the skin by the roots.**[491]** So for this reason and a variety of others, the pelts of this animal are expensive.

It collects many seeds of grain in its cave, and it holds its cheeks out wide and stretched away from its teeth on both sides and it chews the seeds. Therefore, they call a ravenous person by the name of this animal, just as a squirrel either grooms its ears and face with its front paws, or, standing erect, takes up its food and eats while standing on its hind legs and haunches. The Thuringian field is full of these animals because of the abundance and quality of the grain, but the Misenian field is lacking these animals although they are found in the regions of Pegau and Leipzig.

The lemming [**Vormela**] is smaller than the hamster and more varied in color. Indeed, with the exception of the stomach, which is black, the entire body is marked faintly with white, yellow, red, and tawny spots. In fact, the tail, which is 1.5 palms long, has ash-colored hairs mixed with white, but it has black hairs at the tip.

Up till now I have spoken about the classes of mice and weasels and related animals, of which the greatest part goes into subterranean caves. Now I will talk about the porcupine [**Hystrix**], which does indeed withdraw into caves, but during the summer months, as Albertus writes: and it does this in contrast to the habits of the rest of the animals. Some Greeks call it *akanthochoiron* [thorny piglet, eds.] because it bears similarity in appearance to a two-month-old piglet and it is rough with spines like a hedgehog. But yet it has a head similar to that of a hare, ears like those of a human being, and feet like a bear's. Its crest sticks up from the highest part and is white at the top, and the bumps of its skin, which arise from both sides of its face, hold long black bristles growing from them. In fact, the rest of its hairs are also black. The first spines arise from the middle of the back and the flanks, but they are longest on the flanks and at the highest point of the flanks. These individual spines are part black and part white: they are as long as two, or three, or four palms, and if ever it is pleasing, it raises its tail like a peacock, and sends these down into the cave as it is about to enter. When provoked with anger it stretches out its skin, and it fastens missiles on the face of attacking dogs, or it throws a spine with such great force that would stick in wood. It has four long teeth, like a hare, two on the upper jaw, two on the lower. It stays awake during the night, and it sleeps during the day. It eats broken pieces of bread, apples, pears, turnips, and parsnips, and it drinks water, but it greedily guzzles diluted wine. This animal is born in India and Africa, from where it has recently been brought to our country.

During the winter season bears also settle down in hiding places in dens, which their location provides for them. So if the location provides no hiding places, using their front paws as hands, they make burrows from branches and shrubs piled together and constructed so that they do not feel the rain in the dens which they climb into to lie down. And they fear that their tracks, imprinted on the ground, will reveal them to hunters. In addition, the males hide themselves in burrows for 40 days, the females for four months: at which time they give birth to flesh that is white and shapeless, and gradually by licking it they shape it into their own image. Because Ovid was not ignorant about what he wrote:

> A cub which a bear has recently given birth to,
> but the flesh is scarcely alive, the mother molds into limbs by licking
> and she herself restores it to the sort of form which it should occupy.

First of all, they lie hidden and sleep close together for 14 days, and they become so fat from heavy sleep that they settle down and tucking in their front paws they live their lives. And in fact,

they come out of their hiding places again in the spring: the males very fat, the females not as much, because they had given birth during that season, and they free their tight belly by eating the plant of the arum genus. And although the male bears are incredibly eager for slaughter, nevertheless the she-bears will exhibit no savageness if people prostrate themselves before them and turn their faces toward the earth and do not draw breath. **[492]** But they only leave behind those things 492
that smell like they are dead, which they decide that they dislike.

In addition, there are bears that are not familiar to us humans, for the cold regions give birth to many which are either dark gray or black. Of these animals there are two classes: great and small: the latter climb trees more easily and never grow to as great a size as the former. Both kinds eat meat, honey, the fruit of trees, and plants. In fact, Mysia gives birth to white bears, which capture fish like the otter and the beaver.

The lizard also hides in the earth during the winter months, although there are some who say that the life of this animal does not exceed six months. The lizard is generally accustomed to live for the remaining seasons of the year in bramble thickets and thorn bushes. The tongue of this quadruped is forked and hairy: its feet are small, and in the spring its color is green, while it is a yellow-green in the summer.

The copper lizard [**Lacerta Chalcidica**], named for the copper-colored stripes by which its back is marked also hides itself. This same creature is called a venomous lizard, because the wound putrefies if it should bite someone and it usually flows with foul-smelling pus. The form of its body does not differ from that of a green lizard, but only in the color. The water lizard [**Lacerta aquatilis**], whose life is spent in the water and on land, but it is more often in the water, also hides itself. It is born in shady hollows, which are in rich soil, and in certain ditches around city walls. It is small and in addition it has a dissimilarity in color from other lizards, since it is either ash-colored or dark-gray mixed with ash-color. It moves slowly like a tortoise or a salamander. It grows angry if provoked, raises itself up, gets puffed up in a certain way, stands up on straight legs, and with its mouth wide open in its fearful face it stares fiercely at the one who provoked it. And it slowly releases a foul-smelling, milky white sweat continuously while the lizard itself grows completely white. Established in this position, it moves its tail to leap and it tries to flee, because although it bites viciously, it is unable to win, and it would die immediately, when otherwise, if simply beaten, it lives for a long time.

The chameleon [**Chamaeleon**], born in India and Africa, which, as Aristotle writes, has a body in the same shape and form as a lizard, escapes notice [camouflaged]. In fact, like a fish, the sides of this creature, pointed downward and extending straight back are joined with the stomach, and a spiny ridge overhangs the flanks. The appearance is similar to a monkey, which they call Cebus. The tail is long, which has a very narrow tip, and is a tangle of many round structures in the manner of a rawhide whip. When it stands still, it withdraws higher from the ground than the lizard. It bends its legs no differently than a lizard: each of its feet are divided into two parts, which have as great a space between them as the thumb has from the remaining part of the hand. In fact, even these same individual parts are divided into certain small toes: the inner parts of the front feet into three digits, the outer into two, while the inner parts of the rear feet are divided into two digits and the outer parts into three. Moreover, their toes have toe-nails similar to the claws of other animals which are curved. The whole body is rough like that of a crocodile. The large eyes are positioned in a hollow recess, round, and covered with a membrane similar to the skin on the rest of the body. There is an area remaining between the membrane and the eyes, through which it sees. It never covers the eye over completely with skin. The eye turns in a circle and turns around backward to look in every direction, and in this way it perceives whatever it wants. When puffed up, it changes color, but otherwise the black does not differ much from the color of a crocodile, and like a lizard, it is

yellow-green, yet it is varied with black spots like a leopard. Moreover, the alteration of color is on the whole body. For the color of the eyes and tail does not change differently than that of the rest of the body. Its motion is slow to observe, like that of a tortoise. It grows pale when it dies, and the same color remains in the dead creature as when it was alive. It has a rough throat and neck in the same position as a lizard. On no occasion does it have flesh except on its head and jaws, and indeed,
493 the rest of the body is lacking flesh. In fact, **[529{493}** typographical error in folio pagination] there are small pieces of flesh on the jaws and tail, and on that part of the body which is connected to these. It only has blood in its brain, in its eyes, in the highest part of the heart, and in the blood-vessels coming from that part, and in these there is very little blood. The brain is positioned a little bit above the eyes, and it is adjacent to these.

However, with the outer skin of the eyes removed, something is enclosed which shines like a thin copper ring. Many thick membranes which surpass those on the rest of the body are spread out over the entirety of the animal's body. Cut open completely, the animal breathes for a long time, because a very small beat is still present in its heart. When it draws together every part of its body, it especially does so with its flanks. It never contains a spleen of the sort which can be observed. And in fact, it is named for being nourished by the breeze: from which Ovid, a poet who was not only charming but learned wrote:

> And indeed, that animal which is nourished by the winds and the breeze,
> Immediately imitates whatever colors it touches.

Indeed, the gecko hides: its shape is similar to a lizard, its nature to a chameleon. For it lives only on rain water, as well as spiders and honey. This creaturea, Nicander calls *askalabon* (the spotted lizard), and Aristotle *askalabotein* [the spotted lizard]. For the gecko's back is marked with shining spots in the likeness of stars: for which reason it takes its name among the Latin speakers, and it differs in this respect from the lizard. The same creature is called *galeotes* [lizard] by the Greeks. Like a serpent, in the spring it sheds its winter skin as if it were a snake-skin, and unless it is snatched away first, the gecko devours its skin. Whatever the gecko bites is crushed by a sleepy stupor. In Greece, it is poisonous and pestilential, while in Sicily it is harmless. It is hostile to scorpions: it leads its life in tombs, in vaults, and in the areas around doorways and windows. Enclosed in a glass vessel, it is able to live without any food for longer than half a year. Only its eyes become swollen, but it suffers no other ill effect.

The salamander also hides during the winter months. For in the region of Schneeberg, in February of this year the greatest group of salamanders was found, collected from the neighboring areas, massed together in the largest of the certain hollows, once made in the mountain at Muhlberg, but at that time restored. And in November of last year, a live salamander flowed out of a stream in the neighboring woods through the water pipes into this town. Moreover, rain storms and the subsequent pleasant weather stir salamanders from hollows, fissures, and gaps in rocks. This quadruped, which has the same shape as a lizard, because it walks slowly on account of its short legs, the Germans call by the Greek name *molgein* [Molch, salamander]. The head of this animal is large, its stomach is a yellow color, as is also the tip of the tail. The rest of the body is entirely marked with alternating black and yellow spots like stars. It perishes on account of fire, or cold temperatures no differently than from ice. In this way, in fact, the eggs of snakes are piled together in the flame of a furnace, since they are accustomed to extinguish the flame. But yet the eggs themselves are burned up as much as the salamander. Furthermore, when provoked, the salamander vomits out a milky-white liquid. Some think falsely that the gender of this animal is neither male nor female.

The land tortoise [**Testudo terrestris**] also hides in the earth for the entire winter, and spends the time pressed with heavy sleep without any food.

Finally, golden scarabs [beetles, eds.] and crickets, which sing primarily at night, dig in dry earth, so that they might sleep in their hollows during the summer. Likewise, domestic crickets sleep during the winter. For, before autumn, scarabs go deep into the earth until the entire summer has passed by. Country crickets enter the earth before winter, just like black spiders, which live in the same way in cracks in the earth.

But the venomous centipede is born and lives in the trunks of trees, or in posts placed on the earth, or in stakes stuck in the earth, when they rot, from which it gets its name. When these objects are moved or shaken, it comes out, [**530{494}** typographical error in folio pagination] but otherwise it is generally accustomed to hide. It lacks wings, but it has many feet, on account of which some call it by the Latin name multipede [many-legged one], others centipede [100-legged one], and others millipede [1000-legged one]. Whenever it crawls, it bends the middle part of its body like a bow. If it is touched by a stick or some other thing, it draws in upon itself. It is copper-colored, it has a slender body, and three not especially broad, but very long toes, or at the most four. 494

Now bank-dwelling swallows [**Hirundines ripariae**] are among the flying creatures which bury themselves. For indeed, a great number of them hide themselves in nests during the winter months on the banks of rivers, lakes, swamps, and on the shores and rocks of the sea. For this reason, it happens that fishermen sometimes remove them from the water joined together in this way. Moreover, they are called bank-dwelling, because they are accustomed to dig in banks and to construct nests there and to hide. These birds the Greeks call *apodes* [footless ones], not because they are without feet, but because they lack the use of their feet. The Greeks also call them *kupselas* (hollow vessels/boxes), because they bear eggs and they sleep in long hollows made of clay. The entrance to these is narrow, so that at every time of the year they might be able to avoid animals and humans, and to remain safe from the cold in the winter. In this way they differ from both country and domestic swallows [**Hirundines domesticae**], because they have hairy shin-bones. These birds, Pliny says, are those which are seen in the whole sea, and they never go as far toward ships and in a continuous course away from the land as those footless swallows fly. The rest of the class of swallows rest and stop, while these have no rest except in the nest: they either hang in the air or they lie down.

As a matter of fact, during the winter, the following animals about which I have just spoken hide in caves in the mountains, although not only in these: bats, owls, shriek owls, little owls, swallows, starlings, wood-pigeons, turtle-doves, blackbirds, thrushes, crested larks, and hoopoes.

Now, of the class of aquatic animals which hide, some bury themselves during the winter, others during the summer, either in mud or in sand, and indeed they bury themselves in such a way that the entire rest of their body is covered, but the face is free. These fish bury themselves during the winter months: *primadiae* [unknown fish, transl.], the *hippurus* [goldfish or gold mackerel], the Egyptian bolti [**Coracinus**], the moray eel [**Murena**], the sea perch [**Orphus**], the conger eel [**Conger**], the rock-dwelling wrasse [or green wrasse: **Turdus**], the sea wrasse [**Merula**], the perch [**Perca**], the tunny fish [**Thynnus**], the skate [**Raia**], and every species of cartilaginous creature, including snails. On the other hand, the *glaucus* [unknown fish, transl.], the gilt-head and the hake hide themselves during the summer months. The purple murex [**Purpura**], the *buccinum* [whelk], the scallop [**Pecten**], and the dolphin [**Delphinus**] hide for approximately 30 days until they grow old.

Now from the number of animals of which there is life equally on earth and in the water, the aquatic lizard hides during the winter, as I have discussed above. And the crocodile [**Chrocodilus**] also enters its cave for the sake of avoiding the winter weather and it hides there for four months. It endures the bitter cold to such a degree that even when it is not accustomed to hide, it moves

about on the earth during the day and in the water at night. It is rarely reported to be living in Europe nowadays: but drug sellers often hang a dead crocodile from a beam in their offices. Pliny diligently pursued the shape and nature of this creature, he said it is a wicked quadruped, and it is hostile to the earth and rivers equally. This one terrestrial animal is lacking the use of its tongue: the lower jaw imprints a bite by means of the quick upper jaw, and subsequently it is frightening with a row of teeth crowded together like the teeth of a comb. In size it generally exceeds 18 cubits. It lays as many eggs as geese do, and it always incubates them near a predetermined place, to which the Nile flows during the height of the flood season. No other animal grows to a greater size from a smaller beginning. And it is armed with claws, and its skin is impervious to all attacks. A small bird, which in Italy is called the plover, the king of the birds, challenges this animal (the crocodile) when it is well-fed with fish for food and given over to sleep on the shore with a mouth that is fit for eating in order to be open for the sake of its food, first the bird hops in and cleans out the crocodile's mouth, soon its teeth, and even inside its throat by scraping at this sweetness which they are especially greedy for. In this enjoyment, with the crocodile pressed by sleep, the bird catches sight
495 of an ichneumon [mongoose], through these same jaws, and just like a spear sent **[531{495}** typographical error in folio pagination] in gnaws on the animal's belly. In this way it was a greater curse that nature was content with one enemy for this animal. And in this way dolphins traveling in the Nile, whose backs, just as if for this very use, have knife-shaped fins, repel their prey from them, and since they reign only in their river, and because they themselves are otherwise inferior in numbers, they kill by cunning. The crocodile has soft, tender skin on its stomach, and for that reason dolphins immerse themselves when they are frightened, and going under the crocodile they pierce the belly with their fin. In fact, the human race is also an enemy to these animals in the Nile, called Tentyritae for the island on which they live. The length of them is small, but they are at present amazing for the use of intelligence to such a great degree. This creature is terrible against swift flying beasts, and swift against pursuers. But these animals (humans) alone dare to go against them: in fact, they swim in rivers, and positioned on the crocodiles' backs in the manner of those riding horses, with the head tilted back and the mouth open to bite, they insert a club into the mouth, holding the right and left sides of the stick on either end, and they lead them captive to land like harnessed horses. And with a single call they force frightened men to move fresh bodies to a grave: and in this way crocodiles do not swim up to this island, and by smelling the odor of the human race, like Psyllian serpents, they are put to flight. It is said that this animal has weak eyes in the water, outside of its sharper area of vision. For as long as this one certain animal lives, they believe that it grows: moreover, it lives for a long time.

All frogs [Ranae] also hide during the winter months, with the exception of those very small ephemeral ones, which are pale mixed with a gray-blue color and crawl in roads and on shores. For these, because the male and female do not bring forth from a seed when they are joined in coitus, but they seem to arise from wet dirt during summer rain storms, for a long time they can not be in life. And in this way, this small green creature hides itself, which the Greeks call *kalamitein* [grass or reed frog], because it is accustomed to live in reed-beds, although it also climbs trees, and lives in grass, and which they also call *brexanta* [wet one], because the sound of this species presages a future rainstorm. Nor indeed, even though Pliny thinks otherwise, is it [grass frog] mute and without a voice. On many occasions in the spring it seems to come out of the middle of the earth, and to still hide in the middle of it as well. Green frogs [**Rana viridis**], which live in rivers and pools and these indeed are known for their call and for being edible, hide themselves. Bluish and reddish frogs bury themselves, which live in rivers, lakes, swamps, and pools. Some of these are vocal and edible, some are mute and cannot be eaten. But there is proof that these hide in the earth during the winter months, because in the spring not only their offspring are seen in pools, but even the green

frogs themselves. For this reason, what Pliny wrote is not true: it is remarkable that those which were born are enervated in the mud for six months of their lives with no one knowing they are there, and are born again with the spring waters. Likewise, it happens every year by some secret reason. Moreover, the offspring of these have very little flesh, and they are round and black, then recognizable only by the eyes and the tail, these animals Nicander calls *molouridas* [moving tail] because they move their tail, Aratus calls *gurinas* [tadpole] because they are round, and other Greeks call *batrachides*, as you say, little frogs. Afterwards, the front feet of these are formed from the chest, and the tail is divided into the rear legs. Moreover, pale frogs bury themselves in gardens, and these creatures are not to be eaten and are mute. Finally, the toad [**Rana rubeta**], which gets its name from brambles, buries itself and is accustomed to live under thorn-bushes. The poet calls this a toad [bufonem] and the Greeks *phrunein* [a toad]. There are two classes of this creature, the second one earthly [*terrena*], which lives in houses and bushes: the former [*palustris*], which emits the call of its species, lives in swamps. Both kinds are poisonous, each, if it is struck repeatedly with a stick, first, with its body puffed up shoots venom a long way from its hindquarters and then perspires. The milky drops of its sweat are of an extremely offensive and foul smell, and it can generally be killed **[496]** with opium, but it is difficult to kill. Witches use the Rana rubeta [toad] 496
for certain poisons.

The water mouse [**Mus aquaticus**] also hides during the winter in the banks of rivers and streams which it inhabits. It is about the same size as the woodland mouse: it often bites the hands of fishermen, when they pull out river crabs from holes in the banks. It devours little fish, like the river dwelling gudgeon or white fish. It eats the young of the pike [**Lucius**], the *salaris* [trout], the river barbel [**Barbus**], and of other fish. For this reason, when this species of mouse is born with great strength, it is accustomed to inflict devastation on streams.

Even the river dwelling crab [**Cancer fluviatilis**] dwells in river banks and hides in these during the winter, it generally moves about during the summer. But the scorpion, which only Germany knows how to import, does not hide in the earth, but nevertheless it dwells in walls and under rocks.

Now finally in the class of snakes, which are for the most part earth-dwelling, the viper [**Echidne**], which the Greeks call *echidnein* [adder or viper, eds.], climbs under rocks during the winter. It is approximately one cubit long (17.4 inches) and is covered with dark spots on a red background. It first produces its eggs inside itself, then unlike other living animals, it does not bear one offspring at a time, as Nicander and Pliny write, but in one day it bears 20 offspring. Nor do the rest of the offspring, intolerant of the slowness of the birth, break through the sides of the parent, but as spies of serpents tell us, on one single day it generally bears 11 offspring, sometimes more, and it lives curving over them as protection. And in fact, when vipers mingle their bodies together, wound about one another, the female does not bite off the head of the male from the sweetness of pleasure, when it is pushed into her mouth, as Pliny writes. Moreover, not only does the male, but also the female have a tail that is naturally short and seems broken, not long like the rest of the snakes. But they differ from one another in that the females have a broad head, and the males a narrow one. When the male bites and spits out venom, the marks of two sharp teeth appear: when the female bites there are more marks. The viper does not consume milk, in the manner of other snakes, but wine, for which reason Galenus writes that it creeps into a flask filled with wine, and that wine in which a viper has died, is drunk as a remedy for one sick with elephantiasis. People do many things against the bite of a viper, but in particular, Suetonius left behind a writing that warned Caesar Claudius, with an edict having been decreed to the Romans to make a drink from the yew-tree.

Moreover, the dipsas snake [**Dipsas**] is very similar to a smaller viper, and since it is white, two black lines mark its tail. It kills victims by inflicting them with an insatiable thirst, from which it derives its name. In fact, the snake itself is very thirsty and for this reason the belly of the burdened snake is broken open by excessive drinking, and it pours out its heavy burden: some call this a firestorm, and others a waterspout, but the waterspout differs in effect, although the shape of the spout does not differ very much from the snake. For the snake delivers a blow that renders its victim immobile and witless with paralysis: soon with the victim's weapons floating away, they are consumed with itching and weakening of the stomach.

And the blind snake [**Typhlinos, Typhlops**] buries itself in the earth like nearly all the rest of the snakes, or in cracks of rocks: in fact it is called this [caecula, i.e., the blind snake] among the Germans because of its blindness: for this very reason Nicander calls it ***tuphlopa*** [or *typhlopa*: blind-eyed] and others call it ***tuphlinon*** [or *typhlinon*: blind], for indeed it lacks eyes. Its color is green on a yellow background, and it is very resplendent. It is never longer than a foot and never thicker than an inch, just like the viper, as Columella left in writing, and often, when an unwary cow is lying down on top of a pasture, with the heavy creature having been assaulted, the snake presses a bite into it.

In fact, the languid Libyan serpent has eyes: and indeed it is small and slow, but two-headed. Therefore it is able to go forward and backward with either head, whenever it pleases. For this reason its name was given to it *amphisbaena* [**Amphisbaena**]: the colored part of its thick skin rests on the ground, marked with varied spots. The shape of this creature is not unlike that of a cylindrical snake, but it is thicker. It is as thick as the handle of a hoe, and as long as [**497**] an earthworm. 497
When this creature has shed its skin in the spring time, it does not feed on hay, like the other snakes: it gets its name from a walking stick (*baculum*).

The water snake, so called because it swims, enters crevices in the earth or rocky places during the winter months. For this reason, it is called ***hudros*** [or *hydros*: of the water] by the Greeks because of its watery home, and ***chersudros*** [or *chersydros*: of the water and land] because it dwells on land and in the water. And I do not agree with Lucanus, who separates the water serpent from the water snake. Moreover, it is hostile and unfriendly to frogs: its form is no different from the asp, but it differs in its color, which is generally white mixed with an ashy-color. The Calabrican snake appears to be from the class of water snakes, although it is spotted. Virgil describes it in the following verses:

> That evil thing indeed lives in the narrow passages at Calabra,
> The scaly back entwined with the raised chest,
> And the long belly spotted with large marks,
> Which, until any rivers are broken by fountains and until
> the earth grows wet with the spring dew and with the southern rains
> dwells in pools, and living in river banks this evil creature fills
> its foul belly with fish, and with loquacious frogs.
> After the marsh is dried up and the earth cracks open from the heat,
> It leaps up onto dry land and hurling balls of fire
> It savages the fields, since it is violent from thirst and agitated by the heat.

Boas [**Boa**], moreover, are from the class of water snakes, which, on Pliny's authority, grow to such a great size that, during the rule of the divine Claudius, one was killed in the Vatican a whole child was observed in its belly. They are nourished, first of all, on the milky juice of cows, from which they derive their name [cow in Latin is *bos*]: and indeed, there are no kinds of water snakes other than those which are native and indigenous.

The asp [**Aspis**] on the other hand is four feet in length and the width of a lance. It is not one single color: for some are dirt-colored, some are various shades of green, some gray, and some fiery red, especially the kind from Ethiopia. Its dull eyes are situated on its temples, between the eyebrows, in the likeness of two calloused fleshy growths. For this reason it does not cease from blinking, even when it is asleep, but it is easily awoken by the noise of animals. Egypt produces this creature, and Ethiopia, and other regions of Africa. Their consorts, I use Pliny's words, hardly ever wander, unless they are accompanied by their mate, and in this way, when one of them is killed, the other has extraordinary desire for revenge: it pursues the killer, and attacks that one as much as it pleases in an open stream with a conscious understanding. It breaks through all difficulties, it goes to great lengths, and it is not warded off by rivers or swift flight. The ichneumon [mongoose], which is similar to the weasel, is especially hostile to this snake, and in this way, not only does it destroy the snake's eggs, but it even kills the snake itself. Indeed, it often buries itself in mud, and dries out in the sun. Soon, when in this way it covers itself with many coats of mud, it approaches to fight. Raising its tail against the snake, it wards off the ineffective blows of its enemy, until it observes that the snake has its head turned and it attacks the throat. Moreover, Galenus classified asps in three categories: the red asp [*chelidonias*], the asp that resembles the land tortoise [*cherseas*, common European viper, eds.], and the asp that ejects poison at its enemies [*ptyadas*], which is named for its spitting. This is also the kind that Cleopatra used to kill herself. In fact, the asp, since it is intolerant of cold, hides during the winter, closed up and hidden in sand, just as a hamadryad hides in hollow beech or oak trees. For this reason, the asp takes its name. Some call it, as Nicander writes, a *hydron* and others a *chelydron*. For it is similar to a water snake, as far as the head is concerned, but it has a grey back and it is the same width and length as the common eel, and it smells bad. It pursues the young of frogs because they are conspicuous with their tails, and it is an enemy to the great gadfly.

But the horned snake [**Cerastes**] derives its name from its horns, which are doubled in the same manner as those of a snail, and in this way it bears a twin pair of horns on its head: and indeed they are fleshy, **[498]** and as Pliny writes, with the rest of its body hidden, the snake draws birds to 498 itself with the motion of these horns. Otherwise, it is formed in the same shape as a viper. It is the color of dirt, yet in cold regions it is found to be similar in shape and color to the water snake, although it is accustomed to be found rarely in these places. It lives in sand and ruts in Africa: elsewhere it generally lives in cracks of rocks, in which it hides during the winter season. Aristotle passed down [related] that even the Theban snakes are horned.

And the haemorrhoid [**Haemorrhous**] (a snake whose bite was said to cause bleeding from all over the body) goes into cracks in rocks, and it gets its name from flowing blood: for when it bites someone, on the first night blood bursts out of their ears, their nostrils, from their mouth along with spittle, from their bladder along with urine, and from their wounds along with pus. Moreover the gums and the flesh under the fingernails ooze blood, if the female haemorrhoid bites a person. Moreover, it is a foot long, and not very thick, for it gradually comes to an end at its thin tail. Some are gray in color, others a shiny white. Two small horns come from its forehead, likewise fleshy. It crawls more obliquely and slowly and in the same way it makes a noise as if it were crawling over reeds. Its body is similar to a sepedon, but it lacks little horns and it crawls in a different way. Its color is red and it is named for the putrefaction which quickly follows its bite.

In fact, the Porphyrus, as Aelianus passed down, is a palm [hand width, approx. 10 cm] in size, the head is extremely bright white, the rest is a dark red, and it is harmless in its bite, since it lacks teeth. It is found in shallow places in India: when captured, it is hung by its tail, while it is alive they collect the liquid that flows from its mouth in bronze vessels. Next, in the same way, they take the black fluid from a dead one of this species similarly in a different vessel and this substance, given in food or drink with sesame seed gradually kills over the space of one or even two years, and it immediately begins wasting a person away in the manner of hemlock.

The quick-darting snake [**Acontias**], which the Latin speakers call a dart, on the other hand, from cracks in trees projects itself like a spear at an animal that passes by. For this reason, it gets its name. Not only does it hurl itself at an animal from above, but positioned on the ground, if it is provoked, hurling its body like a missile from far off it seeks its enemy.

The cenchris snake, which Nicander calls *cenchrinen*, in fact gets its name for the reason that it is spotted with constant speckles similar in color to millet seed, for which reason Lucanus writes:

> How the cenchris always slithers in a straight path
> and its variegated stomach is colored with many marks,
> How the Theban spotted marble snake is dyed with small spots
> and its color is indistinguishable from dry sand.

The basilisk [**Basiliscus**], on the contrary, is named for the reason that it excels the other snakes in its venom, just as a purple-clad king prevails in royal honors over those whom he is master of. Its head is pointed and its color is golden. The province of Cyrenaica, according to Pliny, produces this creature, which is no greater than the size of twelve inches, and has a white spot on its head as if it were wearing a crown. Its hiss puts all snakes to flight. And it does not spring into action with a twisted coil, as the rest of the serpents do, but advancing tall and straight up in the middle, it destroys shrubs: not only those it comes in contact with, but also those it breathes upon: it burns up plants, and it breaks rocks: so great is the violent strength of this evil creature. It is believed that when a horse is killed by a spear, this creature traveling through the spear by its own strength not only consumes the rider but also the horse. Indeed, often kings wish to see this creature when it is dead, since the poisonous secretion of a weasel is the downfall of such a great monster: thus far it has been pleasing for it to have no equal in nature. They throw weasels into caverns which are easily recognized by their putrefaction alone: the weasels kill with their odor, and they
499 die and their natures create a fight. **[499]** The theologian Cassianus confirms that the basilisk is born from the eggs of birds which the Egyptians call the ibis: he asserts that the monster is born from an egg which the common rooster bears. The basilisk is regarded to be the animal that killed several men in Zuicca with its venom, and for this reason the master of the storeroom in which the creature was, closed the doors and enclosed them with a dirt wall.

The dragon [**Draco**] follows, named for seeing, because it perceives more acutely than other snakes, for which reason the ancients placed it as a guardian of treasure chambers. And they placed it as a guardian in sacred temples, inner sanctums and oracle sites. Moreover, it is beautiful to look upon, for it is entirely black, except for the stomach which is greenish and it seems to have flesh hanging under its long chin, bringing the appearance of a beard because of it, and this flesh is moist with venom. The flesh of each eyebrow is thick. Moreover, it is adorned on both sides of the jaw with a triple row of teeth: yet it does not bite very much. It fights in some regions with eagles, and in Africa and India with elephants. For these animals are each 20 cubits in length. The class of this creature is divided in two: one earthly type, which I have just described, the other winged, which have membranous wings like bats. Cicero left the writing that this is carried into Egypt from the devastation in Libya by the African wind. I had one which was a foot and a half long, which I gave to Ambrosius Fibianus. It was nearly the color of a crocodile and Lucanus writes the following about it:

> You who also crawl, a power harmless to all lands,
> dragons shining with gilded flame,
> blazing Africa creates pestilential dragons,
> You reach the lofty ether with your wings, and chasing the whole herd
> you destroy it by encircling the mighty bulls with your whip-like tail.
> And the elephant is safe in no place, you give all to death,
> And there is no need for you to provide a harmful fate with your venom.

Besides, like some of the serpents described, they do not have to hide at any time of the year in the hottest regions, but they are certainly accustomed to sleep in sand and cracks of rocks.

In contrast, the wood worm [**Teredo**] crawls, for it lacks not only wings but also feet. But it is a copper color and it is born and hides under rotten wood, and it is generally found near centipedes. It is the width of the smallest goose-feather, which we use when we write. It is the length of a centipede, but it is smooth.

Up to this point, I have described animals which hide in the earth during some season of the year: now I will talk about animals that are really and truly called subterranean, that is, about those animals which are born in the earth and almost always live underground, as if hidden. Moreover, these animals lead their lives partially on dry land, partially in the water or they live in subterranean streams. Of the first class are the mole, the mouse, the poisonous frog, the mussel, the pinworm, the earthworm, and cave-dwelling snails: of the second are subterranean fish. These are the animals I will pursue and I will begin with the mole [**Talpa**]. This quadruped is not much different from a mouse, except it is blind, although it has the likeness of eyes, as Pliny writes, if anyone should remove the membrane stretched over them. It is not covered with hair. It can even hear when it is submerged in water, but when removed from the earth, which it inhabits here and there in fields and even more often in meadows and gardens, it can't live for very long. It has short legs, because of which it walks slowly. There are five toes on each of its front feet, four on the back feet, all are armed with sharp claws, with which it digs in the earth. Moreover, it has hair marked with glittering black patches which are white on the young of this species. It eats frogs, even the poisonous
ones, earth worms, and the roots **[500]** of crops and grasses. The pelts of these animals become felt 500
caps and bed-covers.

The subterranean mouse [**Mus subterraneus**] follows, which some call the wild mouse. Servius thinks that it was called a dormouse by Cicero. Virgil writes the following about this mouse:

> Often a small mouse
> Builds dwellings under the earth and makes storehouses,
> Or moles, captured because of their eyes, dig dens,
> And a toad, found in caves, and many monsters which
> The earth produces.

There are two types of this mouse, the smaller and the larger, and the former is not much larger than the smaller domestic mouse. The latter is not much smaller than the larger domestic mouse. In fact, it has a long, thick tail like the smaller domestic mouse. It chews, or more correctly it eats, and sometimes completely consumes the roots of the hops plant, parsnips, turnips and the rest of the legumes. It ravages crops: not only does this pestilential creature always hide in the earth, but it comes out rarely, if ever.

On the other hand, the poisonous frog, which our miners call by their own word *puriphrunos* (fire toad), because of the color of fire which is on it, hides continuously among rocks as if buried and interred. It is born deep inside the earth, and is only found in fissures, small cracks and gaps of rocks, since they hollow these out for themselves. In this way they appear in solid rocks, although there are no holes to be seen, since the rocks are broken open by wedges. Truly in this way the fire toad was discovered at Sneeberg and Mansfield. When this creature is brought out of its subterranean hollows into the light it first swells and begins to puff up, and soon it leaves life. This kind of frog is very often found in Toulouse in Gaul [France], in a sandy red rock marked with white spots from which millstones come. For this reason, this species breaks through all rocks before they can make millstones from them, and if frogs are inactive when they live in millstones, they grow hot, are accustomed to puff up, and when the millstone has broken open they infect the grain with their poison.

The mussel-worm [**Spondylis**], on the other hand, is accustomed to be found inside the earth, wrapped around plants' roots like a spindle whorl, for which reason the Greeks call it *spondulos*, since it bears that appearance. It is the length and width of a small finger: it has a red head, and the rest of the body is white, except the upper part is somewhat black. Whenever it consumes food it swells up. This creature is a pestilence for gardens, since it is not lacking feet, for it has six, and it does not crawl, yet Pliny writes that this species of creeping animal consumes the whole root of plants, the rind of fruits, and wherever the roots of these are covered, it gnaws away that much. In fact, it even eats the roots of the wild cucumber, the black pine-thistle, the centaury, the sulfur-wort, the birthwort, and the woodland grape vine, since no other animal would touch these. But the four-footed worm, which is born in May and runs in fields, is likewise as thick and long as the smallest finger, and like the earthly aphid (or other plant-eating pest), born in legumes, it lives above the earth. Its body is smooth, glittering black, thin and straight. The latter part of the body is attached to the chest. When it is held in the hands, it infects them with a greasy liquid, it pushes out urine as well as blood.

And indeed the roundworms [**Ascarides**], which are small worms, are not of one uniform color, for some are white, some yellow, and some black. Most often they are stirred up by the plow. Moreover, many are found gathered in one certain place. They lay waste to plants: indeed they kill strong crops from underneath by cutting their roots.

But earthworms [**Lumbricus**], which are likewise born inside the earth, and lack eyes are pulled out by the rain. Therefore Plautus's Euclio, when asked about a church filled with gold, says to Strophylus:

> Outdoors, outdoors, O earthworm, you who crawl in this way out of the earth,
> You who are visible nowhere in this way, now when you are visible, you die.
> 501 [**01{501}** typographical error in folio pagination]

In fact, snails on the Balearic islands, as Pliny writes, called cave-dwelling, do not crawl forth from their caves in the earth, and they do not live in the grass, but they cling together in groups like grapes.

Now I will continue on to the second class of subterranean animals, which live in wet places of the earth. For earthworms and other certain animals of this class are born as much in water as on land. Moreover, fossilized fish are found in two classes inside the earth, and they are tapered to a certain extent like eels and they lack a thick skin and scales like the gudgeon. And they have hard and not very pleasant tasting flesh. The larger ones are around two inches thick, the smaller ones around an inch. The former are approximately 16 inches long, the latter about 12. They emit a high-pitched noise. Drug sellers hang them enclosed in glass from a ceiling beam, so that they might present a spectacle for customers. For a long time they feed on bread and other things.

Those animals, however, which rush from rivers into marshy places, leaving through cracks in the river banks penetrate deeper into the earth, and sometimes as far as the closest town in the subterranean cellars, in which wine and beer are accustomed to be stored. And yet Theophrastus writes that they are found near rivers and in watery places. For when water floods the earth, they leave the river beds and go onto land, and when the flood abates, they are left on the dry land. And in this way, following the water they go onto land, then when the water is dried up into vapor they are left behind. They do not live any differently than fish among the rest of those which are salted. Moreover, they perceive nothing when they are in their hiding places because of a numbness of their senses, but when they are dug out they move. And Theophrastus says that they descend into the Black Sea no differently than those fish which ice encircles. For they do not feel or move themselves before they are cooked, having been tossed into a dish.

In fact, we see no fish that are accustomed to live continuously in rivers come up to the earth, left behind after floods in dry areas: they all die. And in this way, since fossilized fish are accustomed to be found in places which the water does not flood, it is certain that they entered that place through cracks and small fissures in the earth. Concerning this matter further, I have diligently turned to the Elbe River of Ortrand, the town which is near the Pulsnitz River. Not only are fossilized fish accustomed to be found in Germany, but even behind the Pyrenees Mountains, as Polybius says in the 34th book of his histories, and on the plain all the way up to the Narbonne River. The Illiberis and Roschinus rivers were carried through this plain, flowing near cities of the same names, which were inhabited by Celts. Therefore, there were said to be fossilized fish on this plain. For the ground on this plain is thin, and a lot of grass grows there, and the spread out stream of a river flows under this through the sand at a depth of two or three cubits. And if ever the plain is flooded with water, the fish go under the earth for the sake of nourishment, for miraculously they grasp the roots of the grass, and they cause the plain to be full of underground fish, which the inhabitants dig up. Fossilized fish are even found near Herculaneum and in many areas of the Black Sea, as Theophrastus published for posterity, and in Paphlagonia, as Eudoxus published. In fact, if we are to believe Seneca, there are pools full of shadows and large spaces under the earth. And animals are born in these, but they are limping and deformed, since they are made in dark air, and derived from fat in the lethargy-causing waters. And as he also writes, that in Caria, around the city of Idimum, when the water bursts forth, whichever ones have perished, those fish consumed, and the new river reveals them to a place that was unknown before that day.

Finally, perhaps because it is pleasing to theologians, demons [**Daemon subterraneus trunculatus**] are able to be considered in the number of natural subterranean animals, that live in certain mines. Moreover, the class of these creatures is divided in two. For there are those which are aggressive and terrifying to look upon, **[538{502}]** which are generally hostile and unfriendly to 502 miners. Such was the one at the Annaberger mine, which killed more than twelve laborers with its breath, which is called a rose-halo. In fact, it emits its fiery breath from its open mouth. And it is said to have been seen in the image of a horse possessing a tall head and neck and savage eyes. And the one at Sneeberg was of this sort: covered with a black hood, it picked up a certain laborer from the ground into the highest part of the large cavernous space, which was rich in silver, and placed his mutilated body in the Georgian mine. In fact, Psellus, when he classified the number of demons into six types, says that this kind is worse than the others, because the material of its skin is thicker. Certain philosophers call these and similar demons, which are harmful and wicked by nature, stupid and lacking reason.

Then there are weak demons, which some of the Germans, as also the Greeks, call hobgoblins, because they are imitators of humans. For they passionately ridicule joy: and they seem to do many things, but they do nothing completely. Some call them mountain devils, since they are commonly noticeable in height, since they are certainly ¾ as tall as a dwarf. Moreover, they appear as old men clothed in the manner of miners, that is, clothed with a shirt, and dressed with a piece of cloth hanging from their loins. These are not accustomed to do damage to miners, but they wander in wells and mines and although they do nothing, they seem to train themselves in every habit of laborers, now they dig cavities, now they pour what is dug out into vessels, and now they maneuver the hauling machine. Although in fact the dirt sometimes irritates the workers, nevertheless it rarely harms them. The hobgoblin never harms them unless it is first provoked by loud laughter or insults. And in this way they are not very different from demons, but they appear to humans much more rarely than those, since everyday they complete part of their work at home and they attend to their beasts of burden. Because they act kindly toward these for our sake and they are in the ancestry of humans, at any rate since they seem to be friends, the Germans placed a name on them, so they call them Gutelos: and you call them Trullis. Nevertheless these had a false sex of male or female and were in slavery among the other nations, especially among the Swedes. But mountain devils work chiefly in caves from which metals are already being dug out or there is the hope that they can be dug out. For this reason miners are not frightened by their labors, but they are more eager, recognizing an omen from them and they work more vigorously.

Animantium nomina Latina Graecaque Germanice reddita, quorum author in lib De Subterraneis animantibus meminit

Latin and Greek Names of Animals translated into German, which the author calls to mind in the book on Subterranean Animals

NB: Latin [or Greek {italics}] and German name
(from Agricola, left column) followed by translation (right column)

Of those that walk (Gradientium)

Alce, elch/elend	moose or elk
Aper, wildschwein	wild boar
Araneus niger, schwarze feldspinne	black [field] spider
Asellus, schefflein: in fenestris uersatur	donkey, lives in windows (?)
Batrachides, kaulkröten	little frogs [tadpoles][kröten toads, eds.]
Blattae, wibel/bzotworme/springtwibel	cock roach or book worm
Brexas, laubfrosch	tree frog
Bufo, kröte	toad
Kalamite, item laubfrosch	tree frog
Kampsiouros, eichorn	dormouse
Caprea, reh	roe deer
Castor, piber	beaver
Cervus, hirs	stag/deer
Chamaeleon, Germanis est ignotus	chameleon, unknown to the Germans
Crocodilus, crocodil	crocodile
Cuniculus, cunlein	rabbit
Dama, ein gemps des horner vor sich gebogen sein	gazelle/antelope
Eleios, Italice gyro	dormouse, gyro in Italy
Erinaceus, igel/eius duo genera, huntsigel und sewigel	hedgehog
Fiber, piber	beaver
Formica, eims	ant
Gale, wisel	stoat/weasel
Glis, grossehaselmaus	dormouse
Gurinoi, Kaulkroten	polywog/tadpole
Hystrix, stachel schwein/dornschwein/porcopick	porcupine
Ibex, steinpock	ibex
Iktis, iltes & aliae sylvestres mustelae	weasel (and other woodland weasels)
Lacerta, grunadex	lizard
Lacerta Chalcidica, kupferadex	Chalcidican lizard
Lacerta aquitilis, wasseradex	water lizard
Lupus, wolff	wolf
Lupus ceruarius, luxs	lynx/wolverine

Lutra, otter	otter
Martes, steinmarter/und paummarter	marten
Meles, daxs	badger
Melium, ein halsband dar under daxs gefuttert/so man den hunden anlegt	badger fur collar
Molourides, kaulkroten	tadpole/pollywog
Mus alpinus, murmelthier	Alpine mouse
Mus araneus, spitzmaus	shrew mouse
Mus agrestis, schormaus	country mouse
Mus lassicius, lassitz	
Mus Noricus , pilche/bilche/zisel/ bilch maus/ziselmaus	gopher
Mus domesticus maior, ratte	rat
Mus Pannonicus	Pannonican mouse
Mus Ponticus, hermlein	Black Sea mouse
Mus aquaticus, wassermaus	water mouse
Mus subterraneus, klein schörmauss	subterranean mouse
Mus sylvestris, haselmaus oder nösmaus	woodland mouse
Mustela domestica, wisel	domestic [=common] weasel
Mustela sylvestris, iltes	woodland weasel
Mugale, spitzmaus	rat
Mus skiouros, eichorn	dormouse
Noerza, noerz	mink
Platyceros, damhirs	wide-horned stag
Pulices terreni, erdfloh	ground fleas
Puriphrunos, feürkrote	fire toad
Rana rubeta, krote	toad
Rana temporaria, reinfroschlein	pure frog
Rana venenata fossilis, feürkrote	fire toad
Rana viridis parva, laubfrosch	small green frog, foliage [tree] frog
Ranae virides, sublividae, subcincreae frosche	green, slate, or gray frogs
Rupicapra, ein gemps des horner hinder sich gebogen sein	mountain goat
Salamandra, molch	salamander
Scarabeus, de quo hic loquimur, sewkefer	beetle [scarab] (about which we are speaking here)
Skiouros, eichorn	dormouse
Sorex, mitle haselmaus	shrew-mouse
Stellio, Tarantula [*sic*: ? in error]	gecko
[Tarantula	tarantula]
Talpa, molwurff	mole
Tarandrus, reen	reindeer
Testudo, schiltkrote	tortoise
Tragelaphus, brandhirse	wild goat or antelope
Vermis in Maio natus, meiworm	May worm

Viverra, furette und frette	ferret
Vormela, wormlein	lemming; marbled polecat
Ursus, beer	bear
Vulpes, fuchs	fox
Zobela, zobel	sable

Of those that fly (Volantium)

Alauda, lerch	crested lark
Anas immansueta, wilde ente	wild duck
Anser immansueta, wilde gans	wild goose
Apis, pien	bee
Apodes, spirschwalben	bank swallow
Aquila, adler	eagle
Ardeola, reiher	heron
Attagen, haselhun	hazel-hen
Bubo, groshuhu	horned owl
Ciconia, storch	stork
Cornix, Krahe [Krähe]	crow
Corvus aquaticus, wasserrabe	cormorant, water raven
Corvus, cuius caput rubra macula est insigne, holkrahe [-krähe]	crow (whose head is marked with a red spot)
Corvus nocturnus, nachtrabe	night crow [raven]
Crabro, horlitze	hornet
Cuculus, kuckück	cuckoo
Kupselos, spirschwalben	bank swallow
Fulica, wasserhun	coot
Galgulus, hemmerling	yellow bird (perhaps the golden oriole)
Gryllus domesticus, hausheim	domestic cricket
Gryllus agrestis, feldheim	wild cricket
Halcyon fluviatilis, eisvogel	river kingfisher
Hirundines domesticae, hausschwalben	domestic [=house] swallows
Hirundines agrestes, maurschwalben	wild swallows
Hirundines ripariae, spirschwalben	bank-dwelling swallows
Ibis auis Aegyptiaca Germanis ignota	Egyptian ibis bird (unknown to the Germans)
Ikteros, hemmerling	golden oriole
Lagopus, schnevogel	ptarmigan
Locusta, heuschrecke	locust
Mergus, teucher	gull
Merula, amssel und sehamssel	black-bird
Milvus, weih oder hunerahr	kite
Noctua, ranzeule/schlaerule/ stockeule/steineule	little owl
Nuktikorax, nachtrabe	night raven
Olor, schwan	swan
Onocrotalus, schnegans	pelican
Palumbes, holztaube und ringteltaube	wood-pigeon

Perdix, räphun	partridge
Pica, agelester	magpie
Picus, specht	woodpecker
Purrokorax, holkrabe	fire raven
Querquedula, krichentlein	teal
Sturnus, stär	starling
Tetraones, pirckhuner und auerhän	wood grouse
Turdus, krametvogel/zimer/ wein drusschel/zipdrusschel	thrush
Vespa, wespe	wasp
Vespertilio, fledermaus	bat
Ulula, huhu	screech [tawny] owl
Upupa, widerhapfe	hoopoe
Vultur, hasengir	vulture

Of those that swim (Natantium)

Alburnus, weisfisch	white fish
Asellus, in Italia Asino	hake (Asino in Italy)
Aurata, Venetiis Auraia	gilthead (Auraia in Venice)
Barbus, parme	river barbel
Buccinum, in Liguria corneto	kind of shellfish (corneto in Liguria)
Cancer fluviatilis, krebs	river crab
Conger, in Italia congro	conger eel (congro in Italy)
Coracinus, Neapoli coracino	Egyptian bolti (coracino in Naples)
Delphinus, mehrrschwein/dar von kompt salspeck	dolphin
Glaucus	unknown fish
Gobio fluviatilis, schmerle	gudgeon or loach
Hippurus	goldfish
Lucius, hecht	pike, pike
Merula, Massiliae roquando	wrasse (roquando in Marseille)
Murena, in Italia murena	moray eel (murena in Italy)
Orphus, in Sicilia cernha	sea perch (cernha in Sicily)
Pisces fossiles, peifter und merputten/ qui sunt crassiores	fish fossils
Pecten, Venetiis cappe	scallop (cappe in Venice)
Perca, berse	perch
Primadia	
Purpura, in Graecia porphyro	purple murex (porphyro in Greece)
Raia, roch	skate or ray
Salar, fhure	an unidentified sea fish perhaps a trout
Salmo, salm/laxs	salmon
Sturio, stöz	sturgeon
Thynnus thunno	tunny fish
Turdus, Massiliae roquando	green wrasse (roquando in Marseille)

Of those that crawl (Serpentium)

Acontias, ignotus Germanis	dart snake, unknown to the Germans
Amphisbaena, ignota	Amphisbaena, unknown
Aspis, ignota	asp, unknown
Boa, unke	boa
Basiliscus, ignota	basilisk, unknown
Caecula, blindschliche	blindworm/slowworm
Calabricus serpens, , ignota	Calabricus snake, unknown
Xersudros, natter	water snake
Cenchris, ignota	Cenchris snake, unknown
Cerastes, hornichte schlange	horned snake
Dipsas, ignota	dipsa snake, unknown
Draco, drach	dragon
Dryinos, eichschlange	Dryinos
Haemorrhous, ignota	haemorrhois, unknown
Natrix, natter	water snake
Porphyrus, ignota	Porphyros, unknown
Scytale, ignota	cylindrical snake, unknown
Sepedon, ignota	snake
Tuphlinos, blindschleiche	[*Typhlinos*], blind snake
Tuphlops, blindschleiche	[*Typhlops*], blind snake
Vipera, Italis marasso	viper, marasso in Italy
Hudros, natter	[*Hydros*], water snake [adder or viper]

Of worms (Vermium)

Ascarides, erdworme	earthworm/pinworm/roundworm
Lumbricus, reinworm	earthworm/pure worm
Scolopendra, nassel	venomous centipede/nereid worm
Spondylis, engerle	mussel [worm]
Teredo, kupferworm	wood worm

Of demons/supernatural beings (Daemonum)

Daemon subterraneus truculentus bergteufel mitis bergmenlein/ kogel/guttel	mountain devil/mitis

Index in Librum
De subterraneis animantibus secundus

Second Index in the book about Subterranean Animals

NB: Words in *italics* are transliterated from the Greek. Pagination shown for the original text and may be found in the translation by reference to the boldfaced numbers in brackets [XXX] that delimit the beginning and end of each of the original folio pages.

A

Acontias (quick-darting snake) . . . 498 mid.
Aelianus . . . 478 mid., 498 mid.
Aenariae coloni terrae motu & calidarum aquarum effusionibus sedibus exacti (Aenarian inhabitants, driven out by the motion of the earth and the outpouring of hot water from their homes) . . . 480 top
Akanthochoiros, qui & histrix (porcupine [*akanthochoiros* as well as hystrix]) . . . 491 mid.
Alaudae (Crested larks) . . . 482 bot.
    hyeme latent in caver nis montium (hide in the winter in caves of mountains) . . . 494 mid.
Albertus Magnus (Albert the Great) . . . 480 mid.
Alce (elk) . . . 485 top
Ambrosius Fibianus . . . 499 mid.
Amphisbaena . . . 496 bot.
Anates immansuetae (wild ducks) . . . 481 top
Animal incognitu repertim in Norico (unknown animal found in Noricum [former Roman Province now including most of Austria south of the Danube, and excluding Tirol]) 480 mid.
Animantes subterraneae quae proprie & sint & dicantur (Subterranean animals, esp. what they are and what they are said to be) . . . 479 bot., 499 mid.
    those which live on dry land . . . 499 bot.
    those which live in the water . . . 500 bot.
Animantium subterranearum tria genera (the three classes of subterranean animals) . . . 482 top
Animantes omnes natura mutationem sentire (that all animals by nature perceive the change [of the season]) . . . 479 bot.
Animantes quae in regionem e qua egressae sunt non reuertuntur (animals which do not return to the region from which they left) . . . 479, 480 top
    reuertuntur (which return) . . . 480 bot., 481 top.
Animantes frigoris aut caloris uitan di causa locum mutantes (animals that change location to avoid hot or cold) . . . 481 top
Animantes quae noctua uel interdiu in cauernis terrae delitescunt (animals that hide at night or during the day in caves in the earth) . . . 482 top and following
Animantes quae in terra latet aliquo anni tempore (animals which hide in the earth during a certain season) . . . 486 bot. and following up to p. 500
Anseres immansueti (wild geese) . . . 481 top
Aper (wild boar) . . . 485 top
Apes (bee) . . . 481 bot.
Apodes, as well as *kupseloi* (bank swallows) . . . 494 top
Aquatilia quae aliqua anni parte se in coeno uel arena condunt (aquatic animals which bury themselves at a certain time of the year in mud or sand) . . . 494 mid.

Aquila Northusae mortua (the eagle killed in Northusa) 480 mid.
Aquila a lanio Dincelspyhelensi occisa (the eagle killed by the butcher of Dincelspyhelensus) 480 mid.
Aranei nigri (black spiders) 493 bot.
Aratus 495 bot.
Ardeola (heron) 481 top
Aristotle 478 mid., 479 mid., 485 mid., 487 bot., 492 mid., 493 top, 498 top
Aristophanes 486 top
Arces subterraneae (subterranean citadels) 482 mid., bot.
Ascalabus, *askalabotes*, and stellio (gecko) 493 mid.
Ascarides (earthworm/pinworm/roundworm) 499 bot., 500 bot.
Aselli rimis parietum occultantur (donkeys [Aselli] are hidden in cracks of walls) 481 bot.
Asellus (the hake fish hides itself during the summer months) 474 mid.
Asio noctuae species (the appearance of the little horned owl) 486 top
Aspis, & eius genera (Aspis and the classes of this [asp, and its relatives {kinds}]) 497 mid., bot.
Attagenes (hazel-hen) 481 mid.
Aves hyeme in cavis arboribus latetes (birds which hide in hollow trees during the winter) 481 bot.
Aves luteae (yellow birds) 479 mid.
Aves quaedam cur uerno tempore conspiciantur implumes (certain birds are seen without feathers during the spring) 482 top
Aves noctrurniae (nocturnal birds) 485 bot.
Aurata aestiuis mensibus se condit (the gilthead [Aurata] hides itself during the summer months) 494 mid.

B

Basiliscus (basilisk) 498 bot.
Batrachides (tadpoles) 495 bot.
Blattae parietum rimis occultantur (cockroaches [Blattae] are hidden in cracks of walls) 481 bot.
Boae ex natricum genere (boas of the class of water snakes) 497 mid.
Brexas (tree frog [see definition in Animantivm nomina]) (*brexas*, rana) 495 mid.
Bubo (horned owl) 485 bot., 494 mid.
Buccina (shellfish) 494 mid.
Bufo (toad) 495 bot.

C

Cancer fluviatilis (river crab) 496 top
Calabricus serpens (Calabrican snake) 497 top
Caprea (deer [roe deer or wild she-goat]) 485 top
Cassianus theologus (the theologian Cassianus) 499 top
Castor (Beaver (*kastor*)) 484 bot.
Castorea same
Caucasus mons (Caucasus mountain) 482 mid.
Causon quae & dipsas (Causon and dipsas snakes) 496 bot.
Caecula hyeme se condit in terra (blind snake buries [hides] itself in the earth) during the winter) 496 bot.

Cellae subterraneae (underground chambers [burrows]) . . . . 482 mid.
Cenchris serpens (Cenchris snake) . . . . 498 mid.
Centipeda quae & scolopedra (centipede and nereid worm) . . . . 494 top
Cephi Aethiopici (Ethiopian goblet) . . . . 480 mid.
Cerastes (horned snake) . . . . 497 bot.
Cervus (stag) . . . . 485 top
Ciconiae (storks) . . . . 481 mid.
Chameleon . . . . 492 mid.
  aura alitur (is nourished by the wind) . . . . 493 top
Chamaitupeia (brothels) . . . . 483 top
Chelydros (venomous water snake) . . . . 497 bot.
Chersydros (water snake) . . . . 497 top
Cicero . . . . 499 mid., 500 top
Circe . . . . 482 mid.
Cleopatra aspidas ptyadas sibi admouit (applied the venomous asp to herself) . . . . 497 bot.
Columella (small pillar) . . . . 496 bot.
Coenobium subterraneum in Sedonis (underground monastery in Seduna) . . . . 482 mid.
Corpus subterraneun (subterranium bodies and the classes of them) . . . . 479 top
Corvus aquaticus (cormorant) . . . . 481 top
Corvus and *purrokorax* (raven and fire raven) . . . . 481 bot.
Corvus piscis hybernis mensibus secondit (fish hides itself during the winter months) . . . . 494 mid.
Conger . . . . same
Cochleae (snails) . . . . same
Cochleae cavaticae (cave-dwelling snails) . . . . 499 bot., 501 top
Colubri Thebani cornuti (Theban horned serpent) . . . . 498 top
Crabrones sylvestres (woodland hornets) . . . . 481 bot.
Crocodilus (crocodile) . . . . 494 mid.
  insulam Ten tyritarum non adnatat (does not swim to the island of Tentyros) . . . . 495 top
Cuculus (cuckoo) . . . . 481 bot.
Cuniculus (rabbit) . . . . 483 mid.
Cymbri (tribe: see also under K[appa]) . . . . 480 top

D

Dama (antelope) . . . . 485 top
Dantisci bona pars vulgi sub terra habitat (The great part of the Dantiscan people lives under the earth) . . . . 483 top
Daemones subterranei, & eorum du plex genus (subterranean demons and the two classes of them) . . . . 501 bot., 502 top
Delphinus (dolphin) . . . . 494 mid.
Delphinus hostis crocodili (dolphin hostile to crocodiles) . . . . 495 top
Dioscorides . . . . 478 top
Dipsas (dipsas snake) . . . . 496 mid.
Domus in Armenia maiori quales (the types of large homes in Armenia) . . . . 482 mid.
Draco (dragon) . . . . 499 top
  cum aquila & elephante pugnat (fights with the eagle and the elephant) . . . . 499 top
Dryinos . . . . 497 bot.

E

Eleios Aristoteli glis dictus ([*eleios*] called dormouse by Aristotle) . . . . . 487 bot.
Erinaceus hyeme in cavis arboribus se condit (Hedgehog buries [hides] itself in hollow trees in the winter) . . . . . 481 mid., 484 bot.
Echidne (serpent or viper) . . . . . 496 top

F

Iiber [*sic*] = Fibe, & eius descriptio (beaver and its description) . . . . . 484 top
Fibri pelles & testes (hides and testicles of a beaver) . . . . . 484 bot.
Formicae (ants) . . . . . 481 bot.
Fossae Prenestine (Prenestine canals) . . . . . 483 top
Fulica (Coot) . . . . . 481 top
Fulvius Hirpinus uiuaria gliribus in stituit (set up an enclosure for dormice) . . . . . 488 mid.

G

Galgulus (golden oriole) . . . . . 481 top
Geleotes, qui & stellio (gecko/lizard (*geleotes* and gecko) . . . . . 493 mid.
Galenus . . . . . 497 bot.
Gale, quae uisela (*gale* or weasel) . . . . . 489 mid.
Ganeum (common eating house) . . . . . 483 top
Glaucus piscis hybernis mensibus se condit (fish hides itself during the winter months). 494 mid.
Glis (dormouse) . . . . . 481 mid., 488 top
Gliraria (dormouse) . . . . . 488 top
Gothi ex Scandia in Sarmatiam & Daciam (Goths from Scandia moving to Sarmatia and Dacia . . . . . 480 top
Grues ab ultimis quasi terris in untimas discedunt (Cranes leave from the ends of the earth to the other side) . . . . . 481 mid.
Grylli domestici agrestes (savage native crickets) . . . . . 493 bot.
Turinoi . . . . . 495 bot.

H

Halcyones marinae, fluviatiles (marine kingfishers and river-dwelling) . . . . . 485 mid.
Hamester qui à quibusdam cricetus (hamster, which is called cricetus by some) . . . . . 490 mid.
Hamestri appellatio in hominem uo racem apud Germanos (the name of hamster applied to a greedy man among the Germans) . . . . . 491 top
Haemorrhoos . . . . . 498 top
Hippurus piscis (goldfish) . . . . . 494 mid.
Hirundines hyeme in loca tepidiora secedunt (swallows leave warm places during the winter . . . . . 494 mid.
Hirundines ripariae, quae & *apodes* and *kupseloi* (bank-dwelling swallows, as well as *apodes* and *kupseloi*) . . . . . 494 top
Hystrix hybernis mensibus, ut Plinius scribit, in specus secedit: aestiuis: ut Albertus (The porcupine [hystrix], according to Pliny goes into caves during the winter months: according to Albertus during the summer) . . . . . 491 top
Hystricis descriptio (Description of the porcupine) . . . . . same

Hoensteinum (Hoenstein) . . . 483 top
Homerus (Homer) . . . 482 top
Homines cauernas succedentes, qui ex eo Troglodytae (Humans go below into caves,
 which are from Troglodytus) . . . 492 mid.
Homines sylvestres Scricfinniae (Woodland people from Scricfinnia) . . . 482, 486 mid.
Hydros (water snake). . . . 497 top

I, J

Iaculus serpens (Spear snake) . . . 498 mid.
Ibex . . . 485 top
Ibis Aegyptia (Egyptian ibis). . . . 499 top
 in Alpibus visa (seen in the Alps) . . . 480 mid.
Ichneumon [mongoose] crocodilo inimicus (hostile to crocodiles). . 495 [act., 494-5] bot., 496 top
 (especially hostile to) aspidi (to asps [viper]). . . . 497 bot.
Iktoros (weasel) . . . 481 top
Iktis, mustelae genus (the class of weasel) . . . 489 mid.
Iktoros pellis, proverbiu apud Germanos in vilissimum & maxime foetidum scortum
 (The pelt of the weasel, said among the Germans to be worthless and especially
 foul-smelling) . . . the same, bottom

K

Kalamite rana (frog) . . . 495 mid.
Kampsiouros, Latinis sciurus (squirrel, [in] Latin *sciurus*) . . . 487 bot.
Kikkaban, sonus quem ululae edunt (shriek owl, which they call ululae) . . . 486 top
Kobaloi, daemones hominum imitatores (demons that are imitators of humans) . . . 502 top
Kupseloi, quae & *apodes* (bank swallows [in Greek] *Kupseloi*, as well as *apodes*) . . . 494 top

L

Lacerta Chalcidica quae & seps (the Chalcidican lizard as well as snake) . . . 492
Lacerta hybernis mensibus in terra latet (the lizard hides in the earth during the
 winter months. . . . same
Lacerta a stellione quomodo differat (the lizard differs in what way from the gecko) . . . 493 mid.
Lacerta aquatilis (water lizard) . . . 492 mid.
Lacerta viridis (green lizard). . . . same
Lagopus (ptarmigan) . . . 485 mid.
Lepus (hare) . . . same, top
Locustae in Pannonias, Dacíã & Lygíos proximis annis involarunt (Locusts flew
 into Pannonia, Dacia and Lygia last year) . . . 480 mid.
Lubeci bona pars vulgi sub terra habitat (good part of the Lubecian people lives
 under the earth) . . . 483 top
Lucanus . . . 498 mid., 499 mid.
 reprehensus (criticized) . . . 497 top
Lumbrici (earthworms) . . . 499 bot., 500 bot.
Lupus (Wolf) . . . 485 top
Lupus ceruarius (lynx/wolverine) . . . 483 mid.
Lutra, & eius descriptio (otter and its description) . . . 483 mid., 484 top, mid.

M

Martialis (Martial) . . . . 488 top, 490 bot.
Meles (badger) . . . . 483 mid, bot., 485 top
  caninus suillus (resembling a young pig) . . . . 485 top
Melia (badger skin collars) . . . . same, mid.
Mergus (gull). . . . . 481 mid.
Merulae (black-birds) . . . . same, bot., 494 mid.
Merula piscis (wrasse fish) . . . . 494 mid.
Molge Graeco nomine Germanis, quae salamandra (salamander, by the Greek
  name from the Germans) . . . . 493 mid.
Molourides ranae (tadpole/pollywog) . . . . 495 bot.
Multipeda & millipeda, quae & scolopendra (multipede and millipede, as well as centipede
  . . . . 494 top
Murena hybernis mensibus se condit (moray eel hides itself during winter months). . . same, mid.
Mus Alpinus (alpine mouse). . . . . 486 bot., 487 top
Mus aquitilis (water mouse) . . . . 496 top
Mus araneus , qui & *mugale* (shrew mouse as well as *mugale*). . . . . 489 top
Mus lassicius (Lassician mouse). . . . . 488 mid.
Mus Noricus, qui citellus (gopher) . . . . 488 mid.
Mus Pannonicus (Pannonican mouse) . . . . same
Mus Ponticus (Black Sea mouse). . . . . 481 bot.
Mus skiouros (dormouse) . . . . 487 bot.
Mus sylvestris (wood mouse). . . . . 488 bot.
Mus subterraneus, qui & agrestis (subterranean mouse, that and country mouse) . . . . 500 top
Mustela quae proprie *gale* (weasel which is especially known as *gale*) . . . . 489 mid.
  iktis ibid (as above) . . . . same, mid.
  quae martes ibidem (which is known as marten). . . . . same, bottom
  quae Germanis zobela (which is zobela in German). . . . . 490 top
Mustelarum virus basilisco exitio (venom of weasels as the destruction of basilisks) . . . . 498 bot.

N

Natrix hyeme in cava terrae ingreditur (water snake) goes into hollows in the earth
  during the winter . . . . 497 top
  eius genera ibid. (classes of this animal). . . . . same
Nicander . . . . 493 mid., 495 bot., 496 bot., 497 bot., 498 mid.
  reprehensus (criticized) . . . . 496 mid.
Nitedula (dormouse) . . . . 500 top
Noerza (mink) . . . . 490 mid.
Noctua (little owl). . . . . 485 bot., 486 top, 494 mid.
Noctuarum genera (kinds of nocturnal animals). . . . . 486 top
Nycticorax (night raven). . . . . 485 bot., 486 top

O

Olores (swans). . . . . 481 top
Onocrotalus (pelican). . . . . same, mid.
Opianus (opium) . . . . 478 mid.

Orphus piscis hybernis mensibus se condit (sea perch hides itself during winter months) 478 mid.
Ovidius (Ovid) . . . . same
Ova serpentium in ignem coniecta flammam restinguere (eggs of snakes thrown into fire to extinguish the flame . . . . 495 bot.

P

Palumbes (wood pigeons) . . . . 481 bot., 494 mid.
Pecten (scallop) . . . . 494 mid.
Perca (perch) . . . . same
Perdix (partridge) . . . . 481 mid.
Perfaru réges hyberno tempore Babylone, verno Susis, aestivo in Ecbatanis degebant (Kings of Persia spending the winter in Babylon, the spring in Sufi, and the summer in Ekbatana) . . . . 480 bot.
Puriphrunos (fire toad) . . . . 500 top
Phrunos, rana rubeta (toad) . . . . 495 bot.
Picus (woodpecker) . . . . 481 bot.
Pisces vitandi caloris & frigoris gratia mutant locum (Fish change location to avoid cold or heat) . . . . same, mid., bot.
Pisces fossiles (fossilized fish) . . . . 501 mid., bot.
Platyceros (wide-horned stag) . . . . 485 top
Plinius (Pliny) . . . . 478 mid., 480 mid., 485 top, 488 mid., 494 mid., 497 mid., bot., ... 498 top, bot., 499 bot., 500 bot., 501 top
  reprehensus (criticized) . . . . 495 mid., bot., 496 mid.
Polybius . . . . 501 mid.
Porphyrius . . . . 478 mid.
Porphyrus serpens (Porphyrus snake) . . . . 498 mid.
Prester à dipsade differt (A waterspout differs from a snake) . . . . 496 bot.
Prenestinae fossae (Praenestine ditches [trenches; mines]) . . . . 483 top
Primadiae . . . . 494 mid.
Psellus . . . . 502 top
Psyllorum olfactu serpentes fugantur (snakes are put to flight by the scent of the Psylli tribe) . . . . 495 mid.
Pufhardum (Pufhard in Thuringia) [now Buchfart] . . . . 482 bot.
Purpua (purple murex: purple snail) . . . . 494 mid.
Purigonoi, bestiolae (Fire-born insects) . . . . 499 mid.

Q

Querquedula (teal) . . . . 481 mid.

R

Raia (skate or ray) . . . . 494 mid.
Ranarum diversa genera (different kinds of frogs) . . . . 495 mid., bot.
Rana rubeta (toad) . . . . same, bot.
Rana quae *kalamite* (frog [Latin] as well as frog [Greek]) . . . . same, mid.
Ranae temporariae (pure frog) . . . . same
Rana venenata (poison frog) . . . . 499 bot., 500 top, mid.

Renum doloris medicamẽtũ (a cure for kidney disease) . . . 485 mid.
Reinesteinum (pure stone) . . . 482 mid.
Rupicapra (mountain goat) . . . 485 top

S

Sal inimicus lacertae aquatili (salt hostile to water lizards) . . . 492 mid.
Salamandra, quae Germanis Graeco nomine *molge* (Salamander, which is named *molge* in Greek by the Germans) . . . 493 mid., bot.
Salmo (salmon) . . . 481 mid.
Scandia . . . 480 top, 482 mid.
Scarabei rutili (red scarab [beetle]) . . . 493 bot.
Scolopendra (centipede) . . . same
Scricfiniae sylvestres homines (Woodland men of Scricfinnia) . . . 482 mid.
Scytale (cylinder snake) . . . 496 bot.
Skiouros (dormouse) . . . 487 bot.
Seneca . . . 501 bot.
Sepedon (snake) . . . 498 mid.
Seps seu lacerta Chalcidica (Seps, or Chalcidican lizard) . . . 492 top
Serpentes hyeme latentes (snakes hiding during the winter) . . . 496 top, mid.
Serpens Calabricus (Calabrican snake) . . . 497 top
Servius . . . 500 top
Sorex (shrew-mouse) . . . 488 mid.
Spondylis vermis (Mussel worm) . . . 499 bot., 500 mid.
Stellio (gecko) . . . 493 mid.
Sturio (sturgeon) . . . 481 mid.
Sturni (starling) . . . 481 bot., 494 mid.
Subterraneum corpus, & eius divisio (Underground bodies and their classification) . . . 479 top
Sibyllae Cumeae antrum (The cave of the Cumaean Sibyl) . . . 482 mid.

T

Talpa (mole) . . . 499 bot.
Tarandrus (reindeer) . . . 485 top
Tenedi insulae piscatores rupiũ specubus pro domibus utũtur ([the way in which] fish on the island of Tenedos use holes in rocks for homes) . . . 482 mid.
Tenyritae . . . 495 top
Teredo (wood worm) . . . 499 mid.
Terrarium quasdam oras onera, quibus premuntur in alias saepe deponere (Burdens which press certain countries of the earth are often lifted onto others) . . . 480 top., mid.
Tetraones (wood grouse) . . . 481 mid.
Teutones (Teutoni tribe) . . . 480 top
Thebani colubri (Theban serpents) . . . 498 top
Theophrastus . . . 478 top, 501 top, bot.
    reprehensus de piscibus subterraneis (criticized concerning subterranean fish) . . . 501 top
Testudo terrestris (Land tortoise) . . . 493 bot.
Thynnus (tunny fish) . . . 481 mid., 486 mid.
Tragelaphus (wild goat or antelope) . . . 485 top

Troglodytae. . . . . 482 mid., 486 mid
Trochilos crocodilo dentes & fauces repurgat (The Egyptian plover [trochilos] cleans the teeth and throat of a crocodile) . . . . 494 bot.
Trulli daemones (Trullan demons) . . . . 502 bot.
Turdi (thrushes) . . . . 481 bot., 494 mid.
Turdus piscis (green wrasse) . . . . 494 mid.
Turtures hyeme in cavernis montium latent (Turtle-doves hide in caves of mountains in the winter) . . . . 481 bot., 494 mid.
Tuphlinos, *tuphlinops* (blind snake) . . . . 496 bot.

V

Varro. . . . . 485 mid., 486 top, 488 top
Vermis quadrupes in Maio natus (The four-legged worm born in May). . . . . 494 bot.
Vespertilio (bat) . . . . 485 bot., 486 top, mid., 494 mid.
Vespae (wasps) . . . . 481 bot.
Vipera quae *echidne* (viper also called *echidne*) . . . . 496 top, mid.
Virgilius (Virgil) . . . . 497 top, 500 top
Visela quae *gale* (weasel also called *gale*) . . . . 489 mid.
Viverra (ferret). . . . . 490 mid.
Vlula [Ulua] (Screech [or tawny] owl) . . . . 485 bot., 486 top, 494, mid.
Volucres quae hyeme se condunt in terra (birds that hide themselves in the earth during the winter [in hollows of trees]). . . . . 494 mid.
Vormela (lemming; Marbled polecat) . . . . 491 top
Vpupae [Upupae] (hoopoes) . . . . 481 bot., 494 mid.
Vrsus [Ursus] (bear) . . . . 491 mid., bot.
Vulpes (fox) . . . . 483 top, mid., bot.
Vultur (vulture) . . . . 481 top

X

Xenophon . . . . 482 mid.

Z

Zobela mustelae species (The sable species of weasel). . . . . 490 top, mid.

The end of the index on subterranean animals.

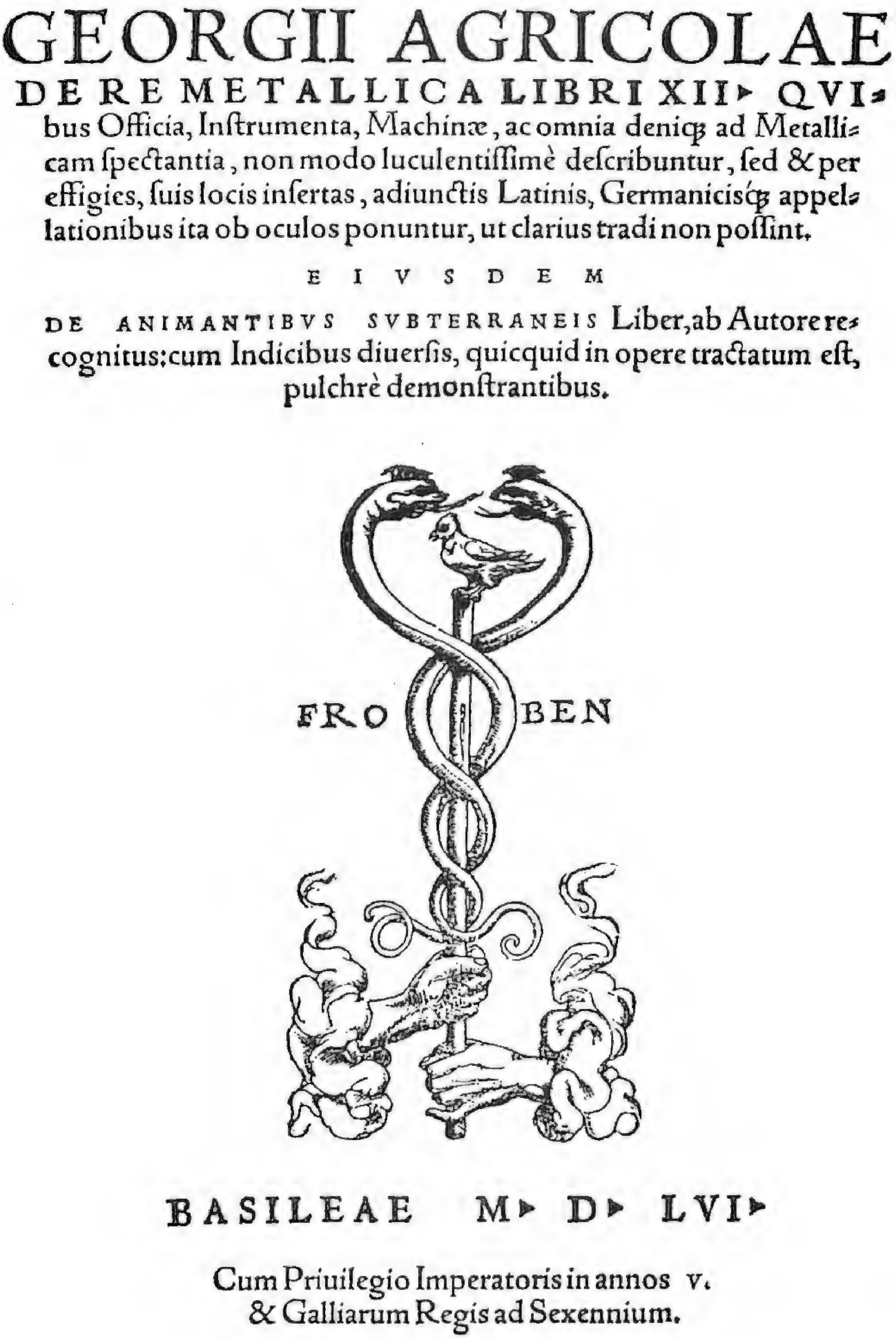
Copyright © 2009 by the California Academy of Sciences
San Francisco, California, U.S.A.

Facsimilae reprint

Georgius Agricola's 1556 edition of *De Animantibus Subterraneis* as it appeared as Libri XII in *De Re Metallica.* The following are scanned images of the photocopy of the original text prepared for the authors by the United States Library of Congress. Because of the delicate binding of the original copy of *De Re Metallica,* some distortion is to be expected in the photocopy.

The authors
26 November 2008

Page intentionally left blank



GEORGII AGRICOLAE

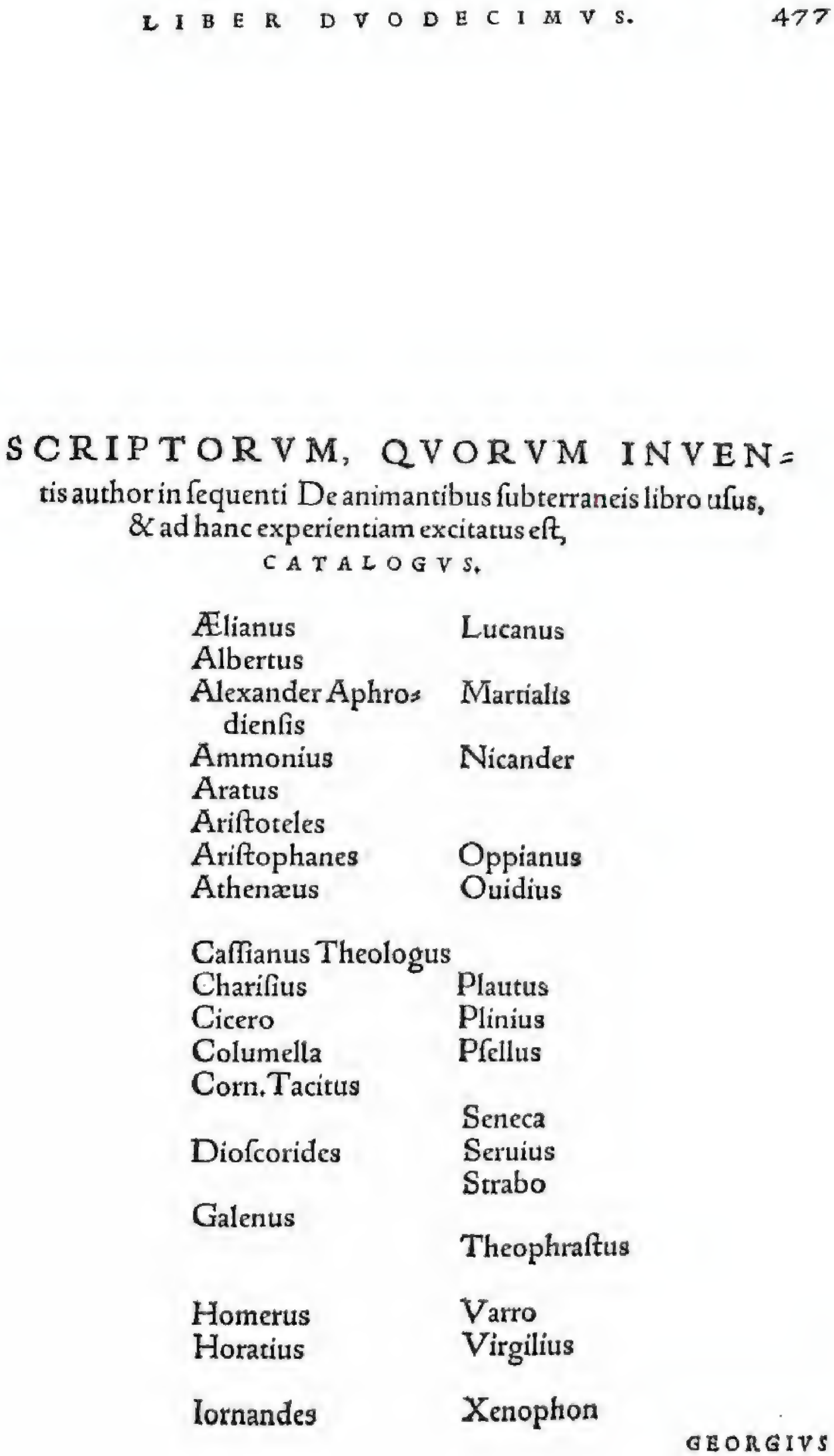
DE RE METALLICA LIBRI XII▸ QVIbus
Officia, Inſtrumenta, Machinæ, ac omnia deniq; ad Metallicam
ſpectantia, non modo luculentiſſimè deſcribuntur, ſed & per
effigies, ſuis locis inſertas, adiunctis Latinis, Germanicisq; appellationibus
ita ob oculos ponuntur, ut clarius tradi non poſſint.

EIVSDEM

DE ANIMANTIBVS SVBTERRANEIS Liber, ab Autore recognitus:
cum Indicibus diuerſis, quicquid in opere tractatum eſt,
pulchrè demonſtrantibus.

BASILEAE M▸ D▸ LVI▸

Cum Priuilegio Imperatoris in annos v.
& Galliarum Regis ad Sexennium.



LIBER DVODECIMVS. 477

SCRIPTORVM, QVORVM INVENtis author in ſequenti De animantibus ſubterraneis libro uſus, & ad hanc experientiam excitatus eſt, CATALOGVS.

Ælianus
Albertus
Alexander Aphrodienſis
Ammonius
Aratus
Ariſtoteles
Ariſtophanes
Athenæus

Caſſianus Theologus
Chariſius
Cicero
Columella
Corn. Tacitus

Dioſcorides

Galenus

Homerus
Horatius

Iornandes

Lucanus

Martialis

Nicander

Oppianus
Ouidius

Plautus
Plinius
Pſellus

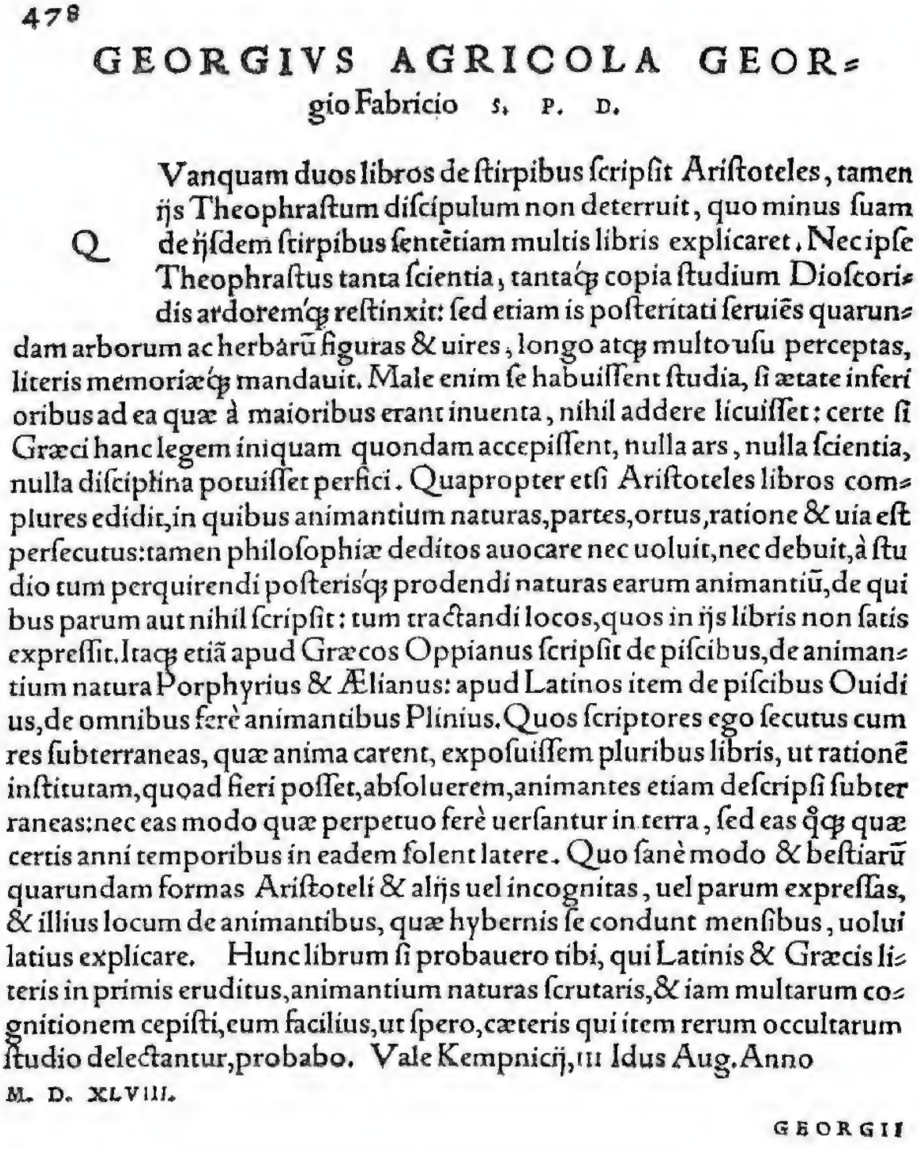
Seneca
Seruius
Strabo

Theophraſtus

Varro
Virgilius

Xenophon

GEORGIVS

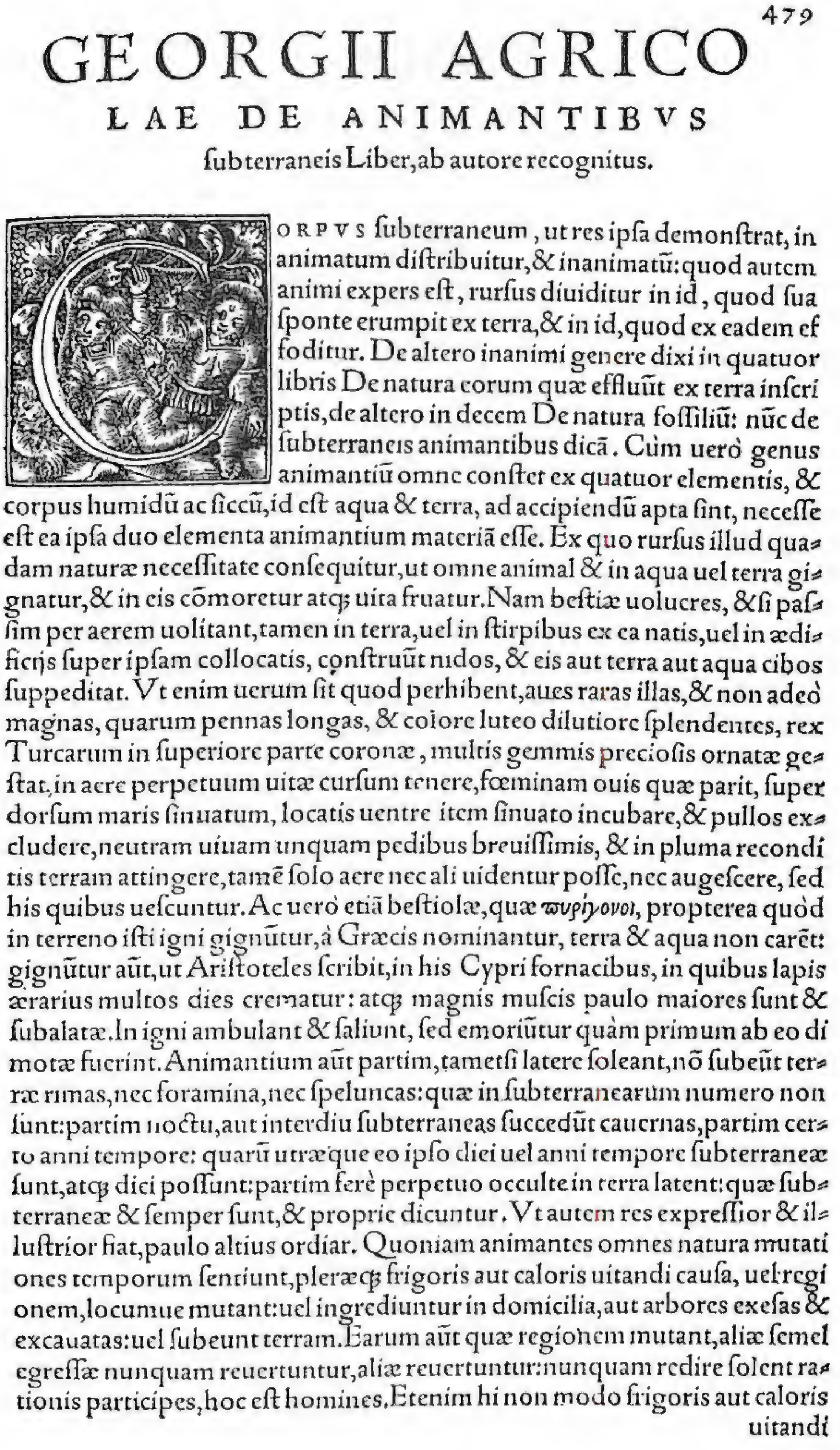


478

GEORGIVS AGRICOLA GEORgio Fabricio S. P. D.

QVanquam duos libros de ſtirpibus ſcripſit Ariſtoteles, tamen ijs Theophraſtum diſcipulum non deterruit, quo minus ſuam de ijſdem ſtirpibus ſentẽtiam multis libris explicaret. Nec ipſe Theophraſtus tanta ſcientia, tantáqꝫ copia ſtudium Dioſcoridis ardoremq́ꝫ reſtinxit: ſed etiam is poſteritati ſeruiẽs quarundam arborum ac herbarũ figuras & uires, longo atqꝫ multo uſu perceptas, literis memoriæq́ꝫ mandauit. Male enim ſe habuiſſent ſtudia, ſi ætate inferioribus ad ea quæ à maioribus erant inuenta, nihil addere licuiſſet: certe ſi Græci hanc legem iniquam quondam accepiſſent, nulla ars, nulla ſcientia, nulla diſciplina potuiſſet perfici. Quapropter etſi Ariſtoteles libros complures edidit, in quibus animantium naturas, partes, ortus, ratione & uia eſt perſecutus: tamen philoſophiæ deditos auocare nec uoluit, nec debuit, à ſtudio tum perquirendi poſteriſq́ꝫ prodendi naturas earum animantiũ, de quibus parum aut nihil ſcripſit: tum tractandi locos, quos in ijs libris non ſatis expreſſit. Itaqꝫ etiã apud Græcos Oppianus ſcripſit de piſcibus, de animantium natura Porphyrius & Ælianus: apud Latinos item de piſcibus Ouidius, de omnibus ferè animantibus Plinius. Quos ſcriptores ego ſecutus cum res ſubterraneas, quæ anima carent, expoſuiſſem pluribus libris, ut rationẽ inſtitutam, quoad fieri poſſet, abſoluerem, animantes etiam deſcripſi ſubterraneas: nec eas modo quæ perpetuo ferè uerſantur in terra, ſed eas q̊qꝫ quæ certis anni temporibus in eadem ſolent latere. Quo ſanè modo & beſtiarũ quarundam formas Ariſtoteli & alijs uel incognitas, uel parum expreſſas, & illius locum de animantibus, quæ hybernis ſe condunt menſibus, uolui latius explicare. Hunc librum ſi probauero tibi, qui Latinis & Græcis literis in primis eruditus, animantium naturas ſcrutaris, & iam multarum cognitionem cepiſti, eum facilius, ut ſpero, cæteris qui item rerum occultarum ſtudio delectantur, probabo. Vale Kempnicij, III Idus Aug. Anno M. D. XLVIII.

GEORGII



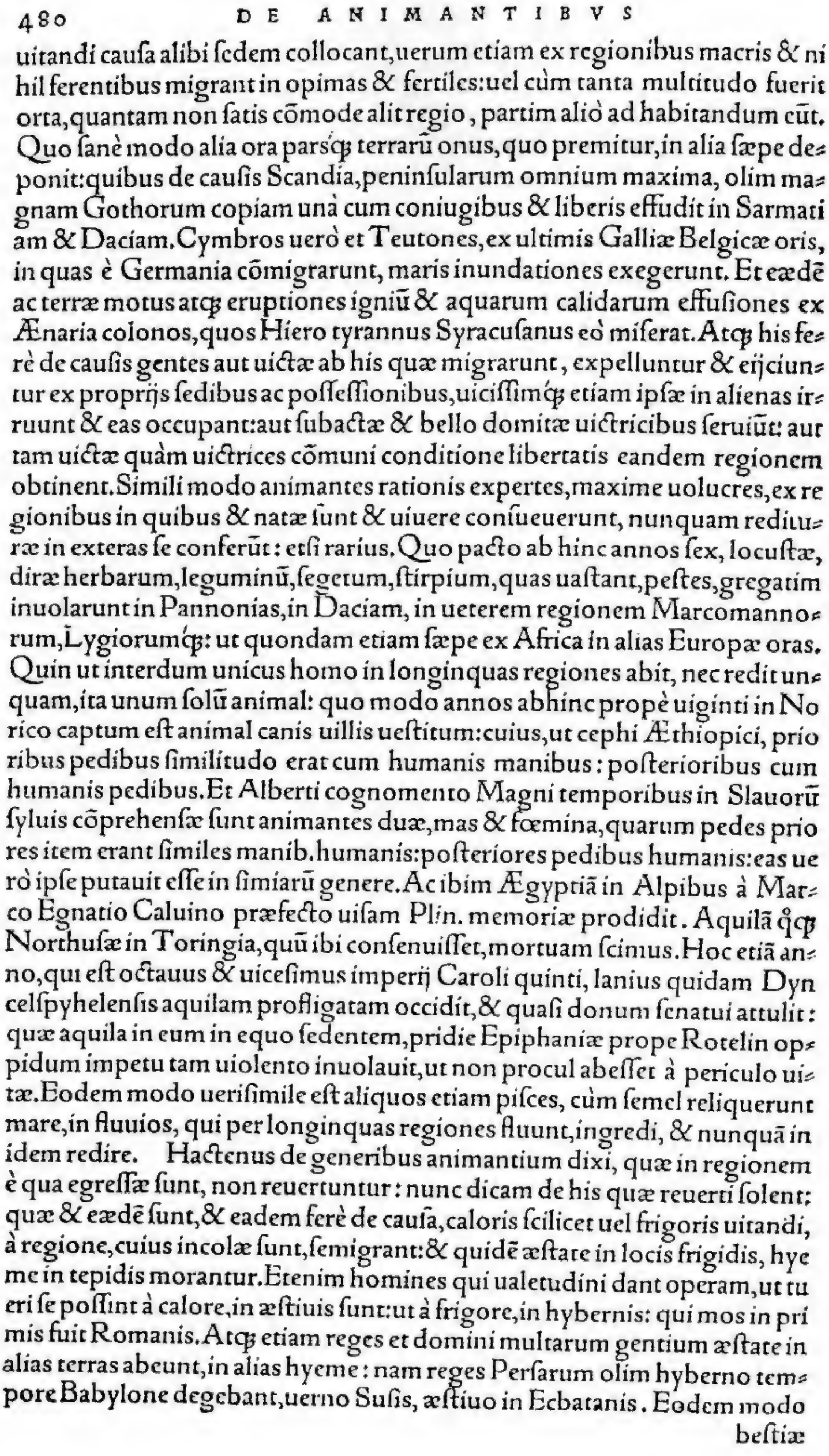
479

GEORGII AGRICOLAE DE ANIMANTIBVS

ſubterraneis Liber, ab autore recognitus.

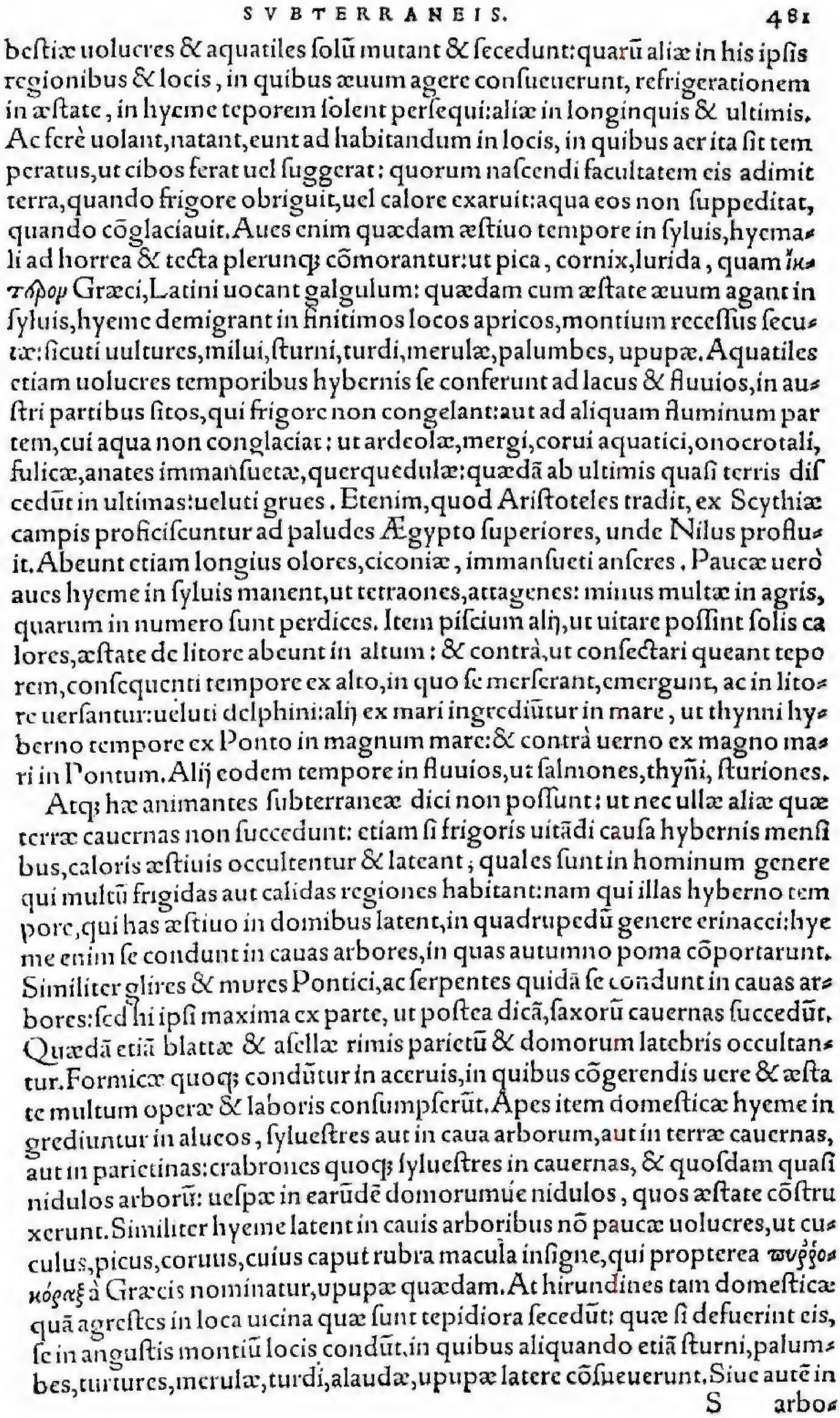
CORPVS ſubterraneum, ut res ipſa demonſtrat, in animatum diſtribuitur, & inanimatũ: quod autem animi expers eſt, rurſus diuiditur in id, quod ſua ſponte erumpit ex terra, & in id, quod ex eadem effoditur. De altero inanimi genere dixi in quatuor libris De natura eorum quæ effluũt ex terra inſcriptis, de altero in decem De natura foſſiliũ: nũc de ſubterraneis animantibus dicã. Cùm uerò genus animantiũ omne conſtet ex quatuor elementis, & corpus humidũ ac ſiccũ, id eſt aqua & terra, ad accipiendũ apta ſint, neceſſe eſt ea ipſa duo elementa animantium materiã eſſe. Ex quo rurſus illud quadam naturæ neceſſitate conſequitur, ut omne animal & in aqua uel terra gignatur, & in eis cõmoretur atq; uita fruatur. Nam beſtiæ uolucres, & ſi paſſim per aerem uolitant, tamen in terra, uel in ſtirpibus ex ea natis, uel in ædificijs ſuper ipſam collocatis, conſtruũt nidos, & eis aut terra aut aqua cibos ſuppeditat. Vt enim uerum ſit quod perhibent, aues raras illas, & non adeò magnas, quarum pennas longas, & colore luteo dilutiore ſplendentes, rex Turcarum in ſuperiore parte coronæ, multis gemmis precioſis ornatæ geſtat, in aere perpetuum uitæ curſum tenere, fœminam ouis quæ parit, ſuper dorſum maris ſinuatum, locatis uentre item ſinuato incubare, & pullos excludere, neutram uiuam unquam pedibus breuiſſimis, & in pluma reconditis terram attingere, tamẽ ſolo aere nec ali uidentur poſſe, nec augeſcere, ſed his quibus ueſcuntur. Ac uerò etiã beſtiolæ, quæ *πυρίγονοι*, propterea quòd in terreno iſti igni gignũtur, à Græcis nominantur, terra & aqua non carẽt: gignũtur aũt, ut Ariſtoteles ſcribit, in his Cypri fornacibus, in quibus lapis ærarius multos dies crematur: atq; magnis muſcis paulo maiores ſunt & ſubalatæ. In igni ambulant & ſaliunt, ſed emoriũtur quàm primum ab eo dimotæ fuerint. Animantium aũt partim, tametſi latere ſoleant, nõ ſubeũt terræ rimas, nec foramina, nec ſpeluncas: quæ in ſubterranearum numero non ſunt: partim noctu, aut interdiu ſubterraneas ſuccedũt cauernas, partim certo anni tempore: quarũ utræque eo ipſo diei uel anni tempore ſubterraneæ ſunt, atq; dici poſſunt: partim ferè perpetuo occulte in terra latent: quæ ſubterraneæ & ſemper ſunt, & proprie dicuntur. Vt autem res expreſſior & illuſtrior fiat, paulo altius ordiar. Quoniam animantes omnes natura mutationes temporum ſentiunt, pleræq; frigoris aut caloris uitandi cauſa, uel regionem, locumue mutant: uel ingrediuntur in domicilia, aut arbores exeſas & excauatas: uel ſubeunt terram. Earum aũt quæ regionem mutant, aliæ ſemel egreſſæ nunquam reuertuntur, aliæ reuertuntur: nunquam redire ſolent rationis participes, hoc eſt homines. Etenim hi non modo frigoris aut caloris

uitandi



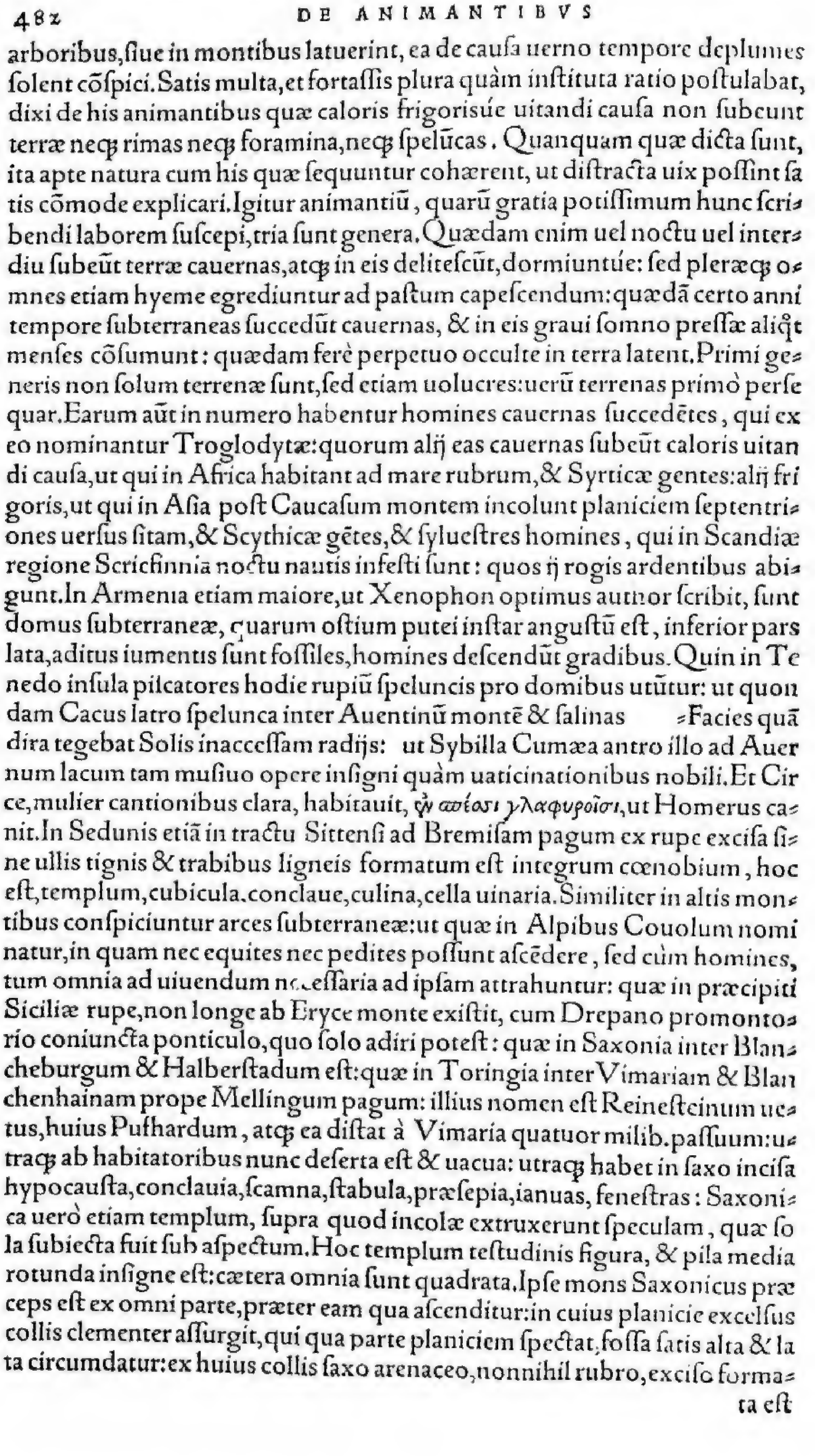
uitandi cauſa alibi ſedem collocant, uerum etiam ex regionibus macris & nihil ferentibus migrant in opimas & fertiles: uel cùm tanta multitudo fuerit orta, quantam non ſatis cōmode alit regio, partim aliò ad habitandum cūt. Quo ſanè modo alia ora parſqꝫ terrarū onus, quo premitur, in alia ſæpe deponit: quibus de cauſis Scandia, peninſularum omnium maxima, olim magnam Gothorum copiam unà cum coniugibus & liberis effudit in Sarmatiam & Daciam. Cymbros uerò et Teutones, ex ultimis Galliæ Belgicæ oris, in quas è Germania cōmigrarunt, maris inundationes exegerunt. Et eædē ac terræ motus atqꝫ eruptiones igniū & aquarum calidarum effuſiones ex Ænaria colonos, quos Hiero tyrannus Syracuſanus eò miſerat. Atqꝫ his ferè de cauſis gentes aut uictæ ab his quæ migrarunt, expelluntur & eijciuntur ex proprijs ſedibus ac poſſeſſionibus, uiciſſimqꝫ etiam ipſæ in alienas irruunt & eas occupant: aut ſubactæ & bello domitæ uictricibus ſeruiūt: aut tam uictæ quàm uictrices cōmuni conditione libertatis eandem regionem obtinent. Simili modo animantes rationis expertes, maxime uolucres, ex regionibus in quibus & natæ ſunt & uiuere conſueuerunt, nunquam redituræ in exteras ſe conferūt: etſi rarius. Quo pacto ab hinc annos ſex, locuſtæ, diræ herbarum, leguminū, ſegetum, ſtirpium, quas uaſtant, peſtes, gregatim inuolarunt in Pannonias, in Daciam, in ueterem regionem Marcomannorum, Lygiorumqꝫ: ut quondam etiam ſæpe ex Africa in alias Europæ oras. Quin ut interdum unicus homo in longinquas regiones abit, nec redit unquam, ita unum ſolū animal: quo modo annos abhinc propè uiginti in Norico captum eſt animal canis uillis ueſtitum: cuius, ut cephi Æthiopici, prioribus pedibus ſimilitudo erat cum humanis manibus: poſterioribus cum humanis pedibus. Et Alberti cognomento Magni temporibus in Slauorū ſyluis cōprehenſæ ſunt animantes duæ, mas & fœmina, quarum pedes priores item erant ſimiles manib. humanis: poſteriores pedibus humanis: eas uerò ipſe putauit eſſe in ſimiarū genere. Ac ibim Ægyptiā in Alpibus à Marco Egnatio Caluino præfecto uiſam Plin. memoriæ prodidit. Aquilā q̊qꝫ Northuſæ in Toringia, quū ibi conſenuiſſet, mortuam ſcimus. Hoc etiā anno, qui eſt octauus & uiceſimus imperij Caroli quinti, lanius quidam Dyncelſpyhelenſis aquilam profligatam occidit, & quaſi donum ſenatui attulit: quæ aquila in eum in equo ſedentem, pridie Epiphaniæ prope Rotelin oppidum impetu tam uiolento inuolauit, ut non procul abeſſet à periculo uitæ. Eodem modo ueriſimile eſt aliquos etiam piſces, cùm ſemel reliquerunt mare, in fluuios, qui per longinquas regiones fluunt, ingredi, & nunquā in idem redire. Hactenus de generibus animantium dixi, quæ in regionem è qua egreſſæ ſunt, non reuertuntur: nunc dicam de his quæ reuerti ſolent: quæ & eædē ſunt, & eadem ferè de cauſa, caloris ſcilicet uel frigoris uitandi, à regione, cuius incolæ ſunt, ſemigrant: & quidē æſtate in locis frigidis, hyeme in tepidis morantur. Etenim homines qui ualetudini dant operam, ut tueri ſe poſſint à calore, in æſtiuis ſunt: ut à frigore, in hybernis: qui mos in primis fuit Romanis. Atqꝫ etiam reges et domini multarum gentium æſtate in alias terras abeunt, in alias hyeme: nam reges Perſarum olim hyberno tempore Babylone degebant, uerno Suſis, æſtiuo in Ecbatanis. Eodem modo

beſtiæ



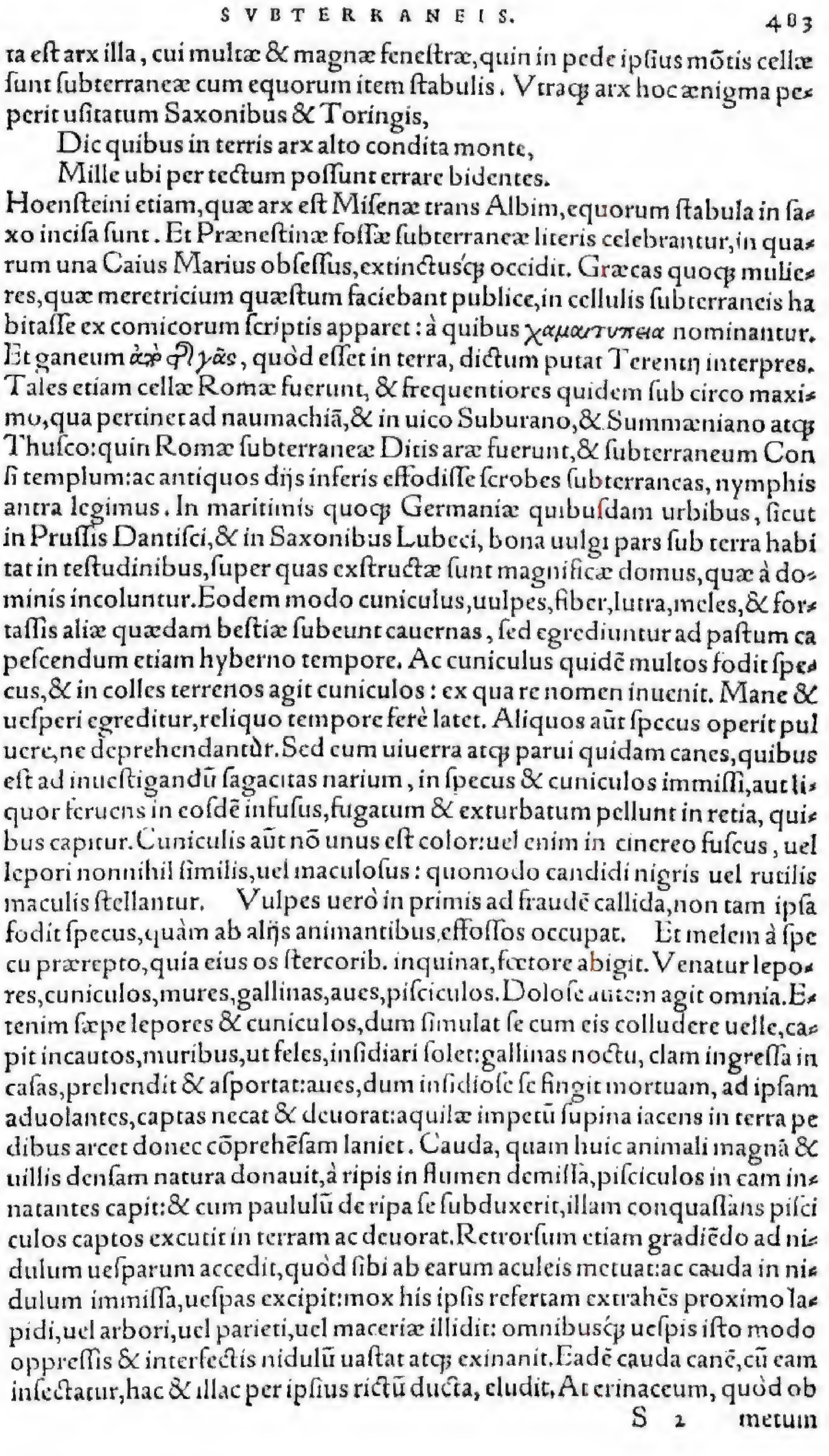
beſtiæ uolucres & aquatiles ſolū mutant & ſecedunt: quarū aliæ in his ipſis regionibus & locis, in quibus æuum agere conſueuerunt, refrigerationem in æſtate, in hyeme teporem ſolent perſequi: aliæ in longinquis & ultimis. Ac ferè uolant, natant, eunt ad habitandum in locis, in quibus aer ita ſit temperatus, ut cibos ferat uel ſuggerat: quorum naſcendi facultatem eis adimit terra, quando frigore obriguit, uel calore exaruit: aqua eos non ſuppeditat, quando cōglaciauit. Aues enim quædam æſtiuo tempore in ſyluis, hyemali ad horrea & tecta plerunqꝫ cōmorantur: ut pica, cornix, lurida, quam ἴκτερον Græci, Latini uocant galgulum: quædam cum æſtate æuum agant in ſyluis, hyeme demigrant in finitimos locos apricos, montium receſſus ſecutæ: ſicuti uultures, milui, ſturni, turdi, merulæ, palumbes, upupæ. Aquatiles etiam uolucres temporibus hybernis ſe conferunt ad lacus & fluuios, in auſtri partibus ſitos, qui frigore non congelant: aut ad aliquam fluminum partem, cui aqua non conglaciat: ut ardeolæ, mergi, corui aquatici, onocrotali, fulicæ, anates immanſuetæ, querquedulæ: quædā ab ultimis quaſi terris diſcedūt in ultimas: ueluti grues. Etenim, quod Ariſtoteles tradit, ex Scythiæ campis proficiſcuntur ad paludes Ægypto ſuperiores, unde Nilus profluit. Abeunt etiam longius olores, ciconiæ, immanſueti anſeres. Paucæ uerò aues hyeme in ſyluis manent, ut tetraones, attagenes: minus multæ in agris, quarum in numero ſunt perdices. Item piſcium alij, ut uitare poſſint ſolis calores, æſtate de litore abeunt in altum: & contrà, ut conſectari queant teporem, conſequenti tempore ex alto, in quo ſe merſerant, emergunt, ac in litore uerſantur: ueluti delphini: alij ex mari ingrediūtur in mare, ut thynni hyberno tempore ex Ponto in magnum mare: & contrà uerno ex magno mari in Pontum. Alij eodem tempore in fluuios, ut ſalmones, thyñi, ſturiones.

Atqꝫ hæ animantes ſubterraneæ dici non poſſunt: ut nec ullæ aliæ quæ terræ cauernas non ſuccedunt: etiam ſi frigoris uitādi cauſa hybernis menſibus, caloris æſtiuis occultentur & lateant; quales ſunt in hominum genere qui multū frigidas aut calidas regiones habitant: nam qui illas hyberno tempore, qui has æſtiuo in domibus latent, in quadrupedū genere erinacei: hyeme enim ſe condunt in cauas arbores, in quas autumno poma cōportarunt. Similiter glires & mures Pontici, ac ſerpentes quidā ſe condunt in cauas arbores: ſed hi ipſi maxima ex parte, ut poſtea dicā, ſaxorū cauernas ſuccedūt. Quædā etiā blattæ & aſellæ rimis parietū & domorum latebris occultantur. Formicæ quoqꝫ condūtur in aceruis, in quibus cōgerendis uere & æſtate multum operæ & laboris conſumpſerūt. Apes item domeſticæ hyeme ingrediuntur in alucos, ſylueſtres aut in caua arborum, aut in terræ cauernas, aut in parietinas: crabrones quoqꝫ ſylueſtres in cauernas, & quoſdam quaſi nidulos arborū: ueſpæ in earūdē domorumúe nidulos, quos æſtate cōſtruxerunt. Similiter hyeme latent in cauis arboribus nō paucæ uolucres, ut cuculus, picus, coruus, cuius caput rubra macula inſigne, qui propterea πυῤῥοκόραξ à Græcis nominatur, upupæ quædam. At hirundines tam domeſticæ quā agreſtes in loca uicina quæ ſunt tepidiora ſecedūt: quæ ſi defuerint eis, ſe in anguſtis montiū locis condūt, in quibus aliquando etiā ſturni, palumbes, turtures, merulæ, turdi, alaudæ, upupæ latere cōſueuerunt. Siue autē in



arboribus, ſiue in montibus latuerint, ea de cauſa uerno tempore deplumes ſolent cōſpici. Satis multa, et fortaſſis plura quàm inſtituta ratio poſtulabat, dixi de his animantibus quæ caloris frigoriſue uitandi cauſa non ſubeunt terræ neqꝫ rimas neqꝫ foramina, neqꝫ ſpelūcas. Quanquam quæ dicta ſunt, ita apte natura cum his quæ ſequuntur cohærent, ut diſtracta uix poſſint ſatis cōmode explicari. Igitur animantiū, quarū gratia potiſſimum hunc ſcribendi laborem ſuſcepi, tria ſunt genera. Quædam enim uel noctu uel interdiu ſubeūt terræ cauernas, atqꝫ in eis deliteſcūt, dormiuntue: ſed pleræqꝫ omnes etiam hyeme egrediuntur ad paſtum capeſcendum: quædā certo anni tempore ſubterraneas ſuccedūt cauernas, & in eis graui ſomno preſſæ aliq̄t menſes cōſumunt: quædam ferè perpetuo occulte in terra latent. Primi generis non ſolum terrenæ ſunt, ſed etiam uolucres: uerū terrenas primò perſequar. Earum aūt in numero habentur homines cauernas ſuccedētes, qui ex eo nominantur Troglodytæ: quorum alij eas cauernas ſubeūt caloris uitandi cauſa, ut qui in Africa habitant ad mare rubrum, & Syrticæ gentes: alij frigoris, ut qui in Aſia poſt Caucaſum montem incolunt planiciem ſeptentriones uerſus ſitam, & Scythicæ gētes, & ſylueſtres homines, qui in Scandiæ regione Scricfinnia noctu nautis infeſti ſunt: quos ij rogis ardentibus abigunt. In Armenia etiam maiore, ut Xenophon optimus author ſcribit, ſunt domus ſubterraneæ, quarum oſtium putei inſtar anguſtū eſt, inferior pars lata, aditus iumentis ſunt foſſiles, homines deſcendūt gradibus. Quin in Tenedo inſula piſcatores hodie rupiū ſpeluncis pro domibus utūtur: ut quondam Cacus latro ſpelunca inter Auentinū montē & ſalinas Facies quā dira tegebat Solis inacceſſam radijs: ut Sybilla Cumæa antro illo ad Auernum lacum tam muſiuo opere inſigni quàm uaticinationibus nobili. Et Circe, mulier cantionibus clara, habitauit, ἐν σπέεσι γλαφυροῖσι, ut Homerus canit. In Sedunis etiā in tractu Sittenſi ad Bremiſam pagum ex rupe exciſa ſine ullis tignis & trabibus ligneis formatum eſt integrum cœnobium, hoc eſt, templum, cubicula, conclaue, culina, cella uinaria. Similiter in altis montibus conſpiciuntur arces ſubterraneæ: ut quæ in Alpibus Couolum nominatur, in quam nec equites nec pedites poſſunt aſcēdere, ſed cùm homines, tum omnia ad uiuendum neceſſaria ad ipſam attrahuntur: quæ in præcipiti Siciliæ rupe, non longe ab Eryce monte exiſtit, cum Drepano promontorio coniuncta ponticulo, quo ſolo adiri poteſt: quæ in Saxonia inter Blancheburgum & Halberſtadum eſt: quæ in Toringia inter Vimariam & Blanchenhainam prope Mellingum pagum: illius nomen eſt Reineſteinum uetus, huius Puſhardum, atqꝫ ea diſtat à Vimaria quatuor milib. paſſuum: utraqꝫ ab habitatoribus nunc deſerta eſt & uacua: utraqꝫ habet in ſaxo inciſa hypocauſta, conclauia, ſcamna, ſtabula, præſepia, ianuas, feneſtras: Saxonica uerò etiam templum, ſupra quod incolæ extruxerunt ſpeculam, quæ ſola ſubiecta fuit ſub aſpectum. Hoc templum teſtudinis figura, & pila media rotunda inſigne eſt: cætera omnia ſunt quadrata. Ipſe mons Saxonicus præceps eſt ex omni parte, præter eam qua aſcenditur: in cuius planicie excelſus collis clementer aſſurgit, qui qua parte planiciem ſpectat, foſſa ſatis alta & lata circumdatur: ex huius collis ſaxo arenaceo, nonnihil rubro, exciſo formata eſt

ta eſt

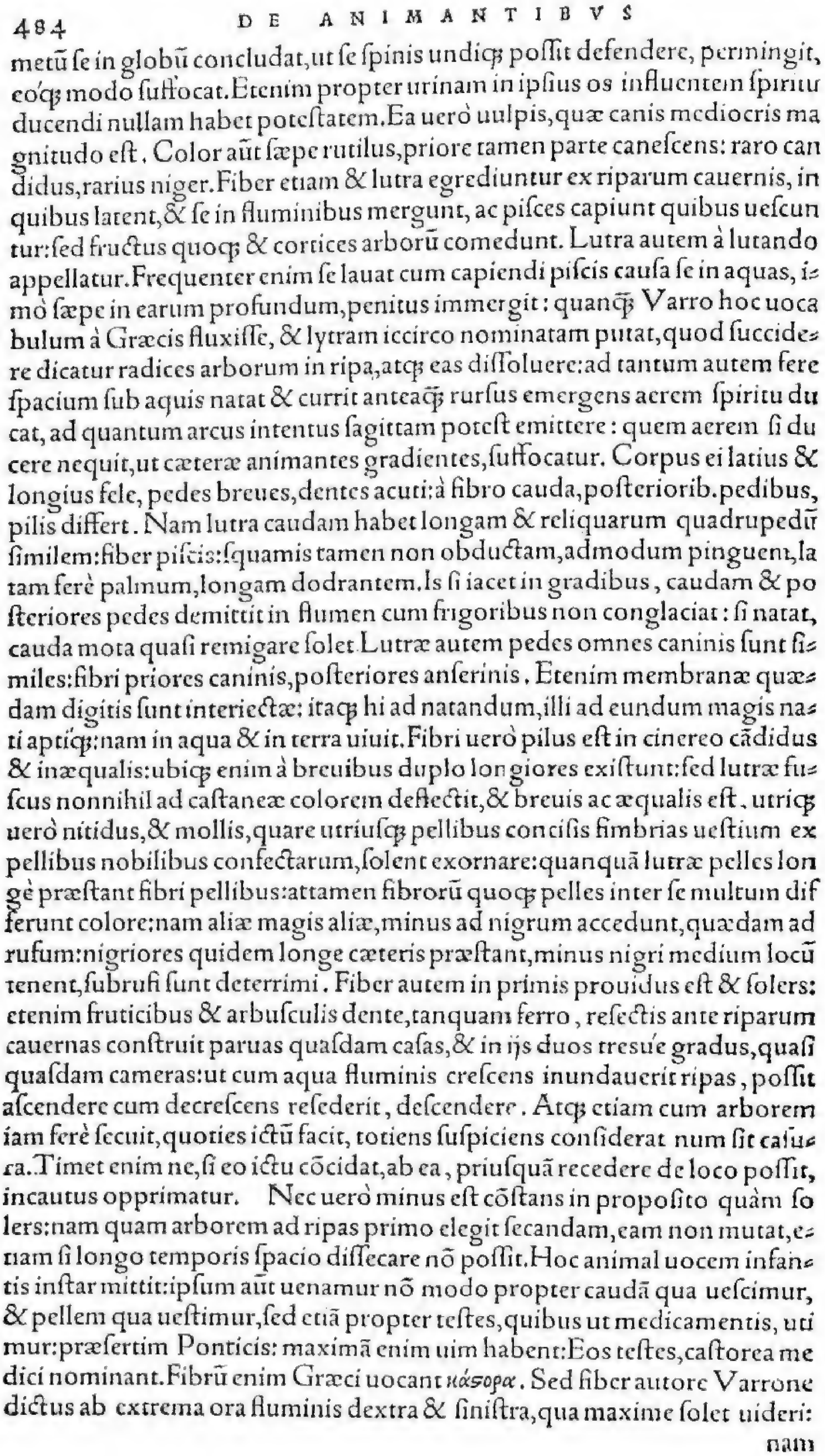


ta eſt arx illa, cui multæ & magnæ feneſtræ, quin in pede ipſius mõtis cellæ ſunt ſubterraneæ cum equorum item ſtabulis. Vtraq; arx hoc ænigma peperit uſitatum Saxonibus & Toringis,

Dic quibus in terris arx alto condita monte,
Mille ubi per tectum poſſunt errare bidentes.

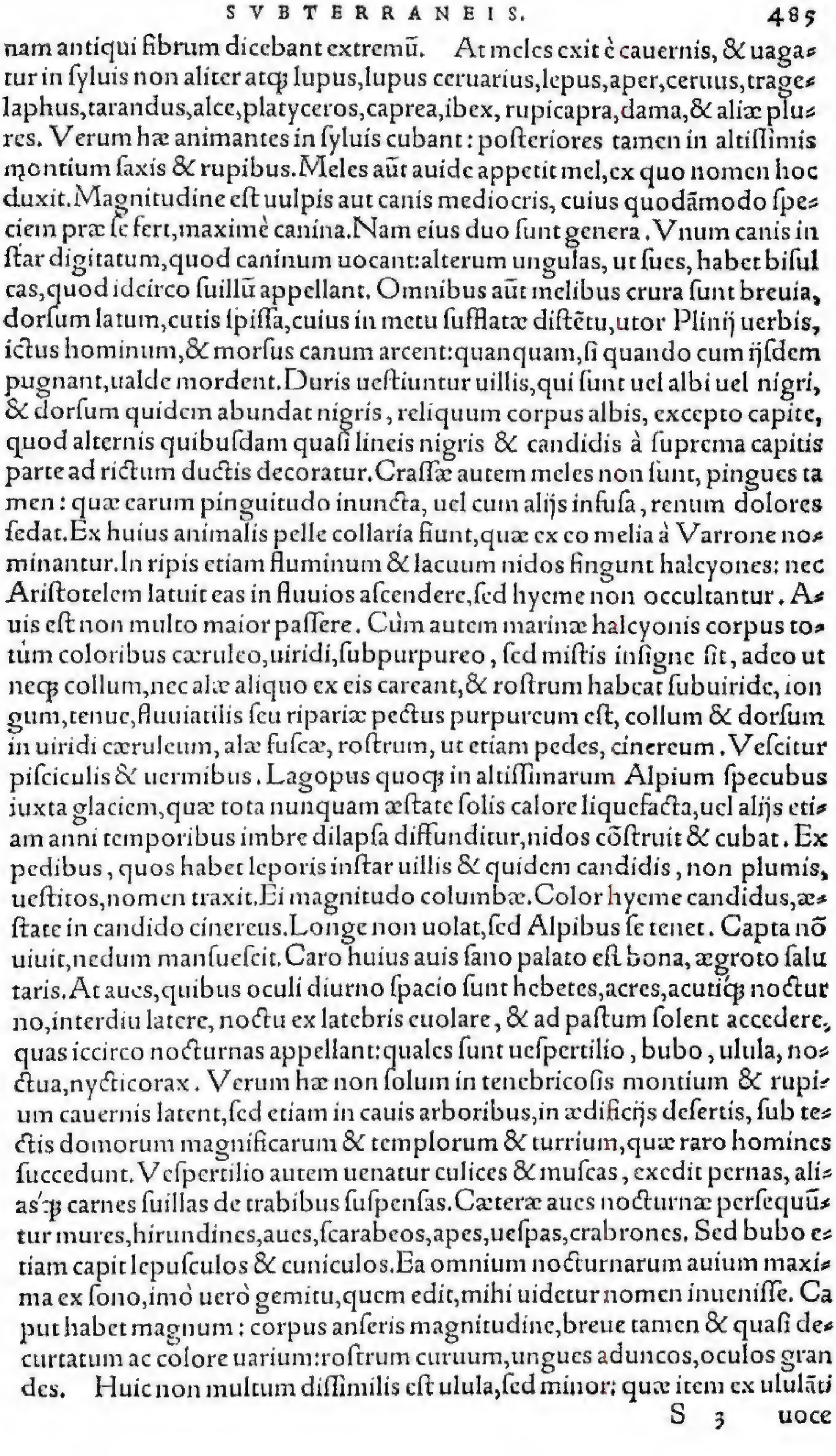
Hoenſteini etiam, quæ arx eſt Miſenæ trans Albim, equorum ſtabula in ſaxo inciſa ſunt. Et Præneſtinæ foſſæ ſubterraneæ literis celebrantur, in quarum una Caius Marius obſeſſus, extinctusq; occidit. Græcas quoq; mulieres, quæ meretricium quæſtum faciebant publice, in cellulis ſubterraneis habitaſſe ex comicorum ſcriptis apparet: à quibus χαμαιτυπεια nominantur. Et ganeum ἀπὸ τῆς γᾶς, quòd eſſet in terra, dictum putat Terentij interpres. Tales etiam cellæ Romæ fuerunt, & frequentiores quidem ſub circo maximo, qua pertinet ad naumachiã, & in uico Suburano, & Summæniano atq; Thuſco: quin Romæ ſubterraneæ Ditis aræ fuerunt, & ſubterraneum Conſi templum: ac antiquos dijs inferis effodiſſe ſcrobes ſubterraneas, nymphis antra legimus. In maritimis quoq; Germaniæ quibuſdam urbibus, ſicut in Pruſſis Dantiſci, & in Saxonibus Lubeci, bona uulgi pars ſub terra habitat in teſtudinibus, ſuper quas exſtructæ ſunt magnificæ domus, quæ à dominis incoluntur. Eodem modo cuniculus, uulpes, fiber, lutra, meles, & fortaſſis aliæ quædam beſtiæ ſubeunt cauernas, ſed egrediuntur ad paſtum capeſcendum etiam hyberno tempore. Ac cuniculus quidẽ multos fodit ſpecus, & in colles terrenos agit cuniculos: ex qua re nomen inuenit. Mane & ueſperi egreditur, reliquo tempore ferè latet. Aliquos aũt ſpecus operit puluere, ne deprehendantùr. Sed cum uiuerra atq; parui quidam canes, quibus eſt ad inueſtigandũ ſagacitas narium, in ſpecus & cuniculos immiſſi, aut liquor feruens in eoſdẽ infuſus, fugatum & exturbatum pellunt in retia, quibus capitur. Cuniculis aũt nõ unus eſt color: uel enim in cinereo fuſcus, uel lepori nonnihil ſimilis, uel maculoſus: quomodo candidi nigris uel rutilis maculis ſtellantur. Vulpes uerò in primis ad fraudẽ callida, non tam ipſa fodit ſpecus, quàm ab alijs animantibus effoſſos occupat. Et melem à ſpecu prærepto, quia eius os ſtercorib. inquinat, fœtore abigit. Venatur lepores, cuniculos, mures, gallinas, aues, piſciculos. Doloſe autem agit omnia. Etenim ſæpe lepores & cuniculos, dum ſimulat ſe cum eis colludere uelle, capit incautos, muribus, ut feles, inſidiari ſolet: gallinas noctu, clam ingreſſa in caſas, prehendit & aſportat: aues, dum inſidioſe ſe fingit mortuam, ad ipſam aduolantes, captas necat & deuorat: aquilæ impetũ ſupina iacens in terra pedibus arcet donec cõprehẽſam laniet. Cauda, quam huic animali magnã & uillis denſam natura donauit, à ripis in flumen demiſſa, piſciculos in eam innatantes capit: & cum paululũ de ripa ſe ſubduxerit, illam conquaſſans piſciculos captos excutit in terram ac deuorat. Retrorſum etiam gradiẽdo ad nidulum ueſparum accedit, quòd ſibi ab earum aculeis metuat: ac cauda in nidulum immiſſa, ueſpas excipit: mox his ipſis refertam extrahẽs proximo lapidi, uel arbori, uel parieti, uel maceriæ illidit: omnibusq; ueſpis iſto modo oppreſſis & interfectis nidulũ uaſtat atq; exinanit. Eadẽ cauda canẽ, cũ eam inſectatur, hac & illac per ipſius rictũ ducta, eludit. At erinaceum, quòd ob

S 2 metum

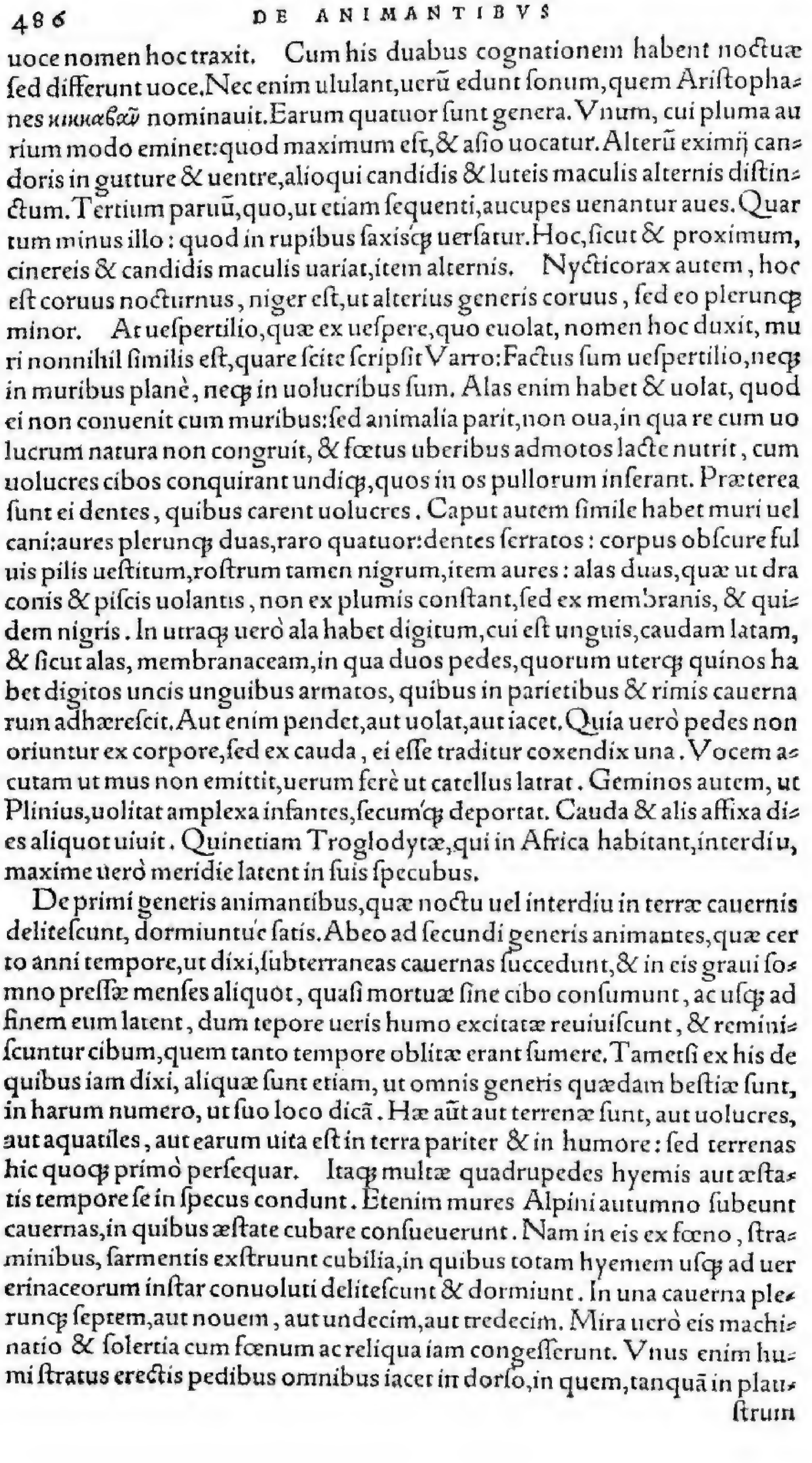


metũ ſe in globũ concludat,ut ſe ſpinis undiq; poſſit defendere, perningit, eoq; modo ſuffocat.Etenim propter urinam in ipſius os influentem ſpiritu ducendi nullam habet poteſtatem.Ea uerò uulpis,quæ canis mediocris magnitudo eſt. Color aũt ſæpe rutilus,priore tamen parte caneſcens: raro candidus,rarius niger.Fiber etiam & lutra egrediuntur ex riparum cauernis, in quibus latent,& ſe in fluminibus mergunt, ac piſces capiunt quibus ueſcuntur:ſed fructus quoq; & cortices arborũ comedunt. Lutra autem à lutando appellatur.Frequenter enim ſe lauat cum capiendi piſcis cauſa ſe in aquas, imò ſæpe in earum profundum,penitus immergit: quanq̃; Varro hoc uocabulum à Græcis fluxiſſe, & lytram iccirco nominatam putat,quod ſuccidere dicatur radices arborum in ripa,atq; eas diſſoluere:ad tantum autem fere ſpacium ſub aquis natat & currit anteaq̃; rurſus emergens aerem ſpiritu ducat, ad quantum arcus intentus ſagittam poteſt emittere: quem aerem ſi ducere nequit,ut cæteræ animantes gradientes,ſuffocatur. Corpus ei latius & longius fele, pedes breues,dentes acuti:à fibro cauda,poſteriorib.pedibus, pilis differt. Nam lutra caudam habet longam & reliquarum quadrupedũ ſimilem:fiber piſcis:ſquamis tamen non obductam,admodum pinguem,latam ferè palmum,longam dodrantem.Is ſi iacet in gradibus, caudam & poſteriores pedes demittit in flumen cum frigoribus non conglaciat: ſi natat, cauda mota quaſi remigare ſolet.Lutræ autem pedes omnes caninis ſunt ſimiles:fibri priores caninis,poſteriores anſerinis. Etenim membranæ quædam digitis ſunt interiectæ: itaq; hi ad natandum,illi ad eundum magis nati aptiq;:nam in aqua & in terra uiuit.Fibri uerò pilus eſt in cinereo cãdidus & inæqualis:ubiq; enim à breuibus duplo longiores exiſtunt:ſed lutræ fuſcus nonnihil ad caſtaneæ colorem deflectit,& breuis ac æqualis eſt, utriq; uerò nitidus,& mollis,quare utriuſq; pellibus conciſis fimbrias ueſtium ex pellibus nobilibus confectarum,ſolent exornare:quanquã lutræ pelles longè præſtant fibri pellibus:attamen fibrorũ quoq; pelles inter ſe multum differunt colore:nam aliæ magis aliæ,minus ad nigrum accedunt,quædam ad rufum:nigriores quidem longe cæteris præſtant,minus nigri medium locũ tenent,ſubrufi ſunt deterrimi. Fiber autem in primis prouidus eſt & ſolers: etenim fruticibus & arbuſculis dente,tanquam ferro, reſectis ante riparum cauernas conſtruit paruas quaſdam caſas,& in ijs duos treſue gradus,quaſi quaſdam cameras:ut cum aqua fluminis creſcens inundauerit ripas, poſſit aſcendere cum decreſcens reſederit, deſcendere. Atq; etiam cum arborem iam ferè ſecuit,quoties ictũ facit, totiens ſuſpiciens conſiderat num ſit caſura.Timet enim ne,ſi eo ictu cõcidat,ab ea, priuſquã recedere de loco poſſit, incautus opprimatur. Nec uerò minus eſt cõſtans in propoſito quàm ſolers:nam quam arborem ad ripas primo elegit ſecandam,eam non mutat,etiam ſi longo temporis ſpacio diſſecare nõ poſſit.Hoc animal uocem infantis inſtar mittit:ipſum aũt uenamur nõ modo propter caudã qua ueſcimur, & pellem qua ueſtimur,ſed etiã propter teſtes,quibus ut medicamentis, utimur:præſertim Ponticis: maximã enim uim habent:Eos teſtes,caſtorea medici nominant.Fibrũ enim Græci uocant κάϛορα. Sed fiber autore Varrone dictus ab extrema ora fluminis dextra & ſiniſtra,qua maxime ſolet uideri:

nam

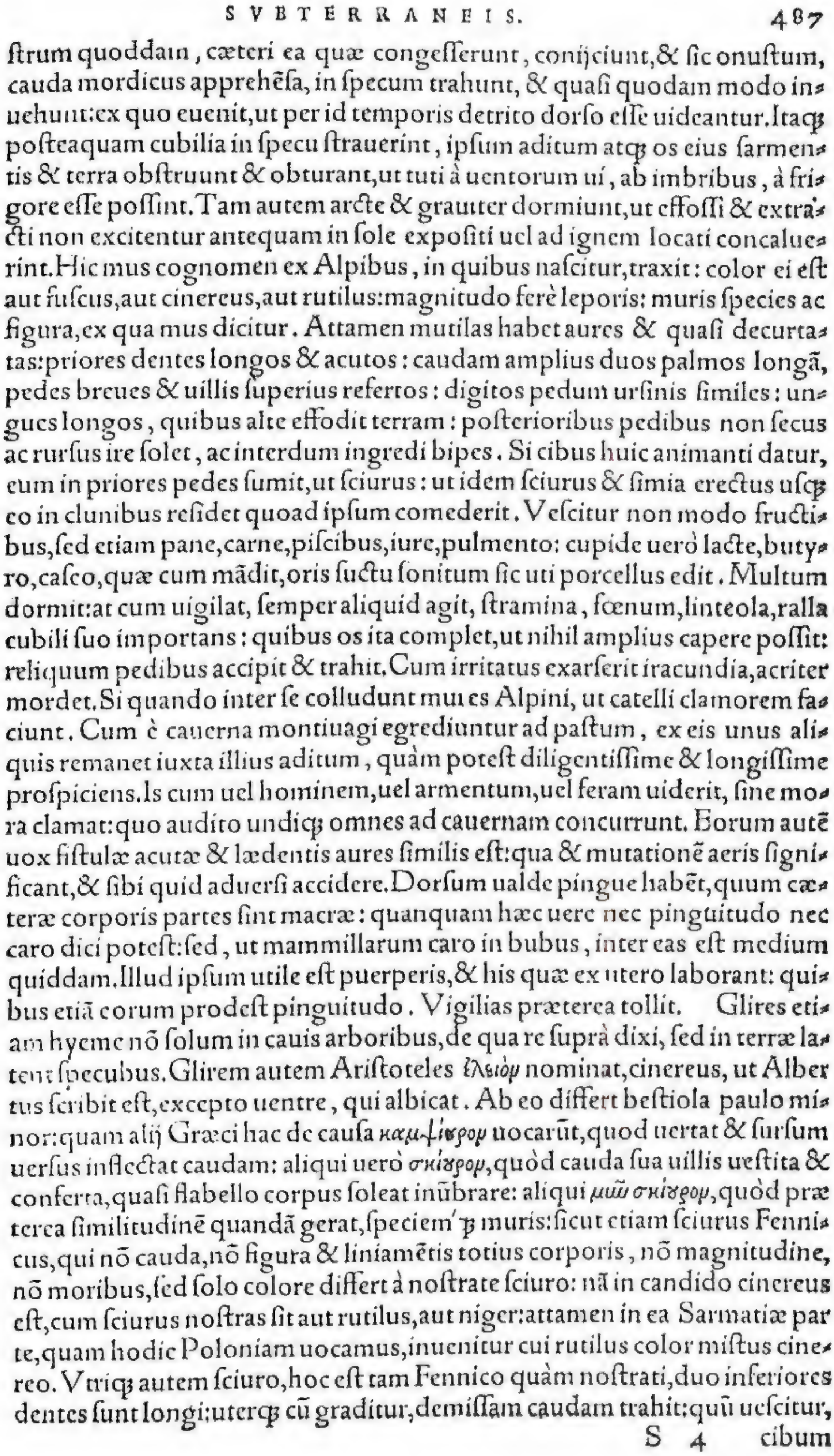


nam antiqui fibrum dicebant extremũ. At meles exit è cauernis, & uagatur in ſyluis non aliter atq; lupus,lupus ceruarius,lepus,aper,ceruus,tragelaphus,tarandus,alce,platyceros,caprea,ibex, rupicapra,dama,& aliæ plures. Verum hæ animantes in ſyluis cubant: poſteriores tamen in altiſſimis montium ſaxis & rupibus.Meles aũt auide appetit mel,ex quo nomen hoc duxit.Magnitudine eſt uulpis aut canis mediocris, cuius quodãmodo ſpeciem præ ſe fert,maximè canina.Nam eius duo ſunt genera. Vnum canis inſtar digitatum,quod caninum uocant:alterum ungulas, ut ſues, habet biſulcas,quod idcirco ſuillũ appellant. Omnibus aũt melibus crura ſunt breuia, dorſum latum,cutis ſpiſſa,cuius in metu ſufflatæ diſtẽtu,utor Plinij uerbis, ictus hominum,& morſus canum arcent:quanquam,ſi quando cum ijſdem pugnant,ualde mordent.Duris ueſtiuntur uillis,qui ſunt uel albi uel nigri, & dorſum quidem abundat nigris, reliquum corpus albis, excepto capite, quod alternis quibuſdam quaſi lineis nigris & candidis à ſuprema capitis parte ad rictum ductis decoratur.Craſſæ autem meles non ſunt, pingues tamen: quæ earum pinguitudo inuncta, uel cum alijs infuſa, renum dolores ſedat.Ex huius animalis pelle collaria fiunt,quæ ex eo melia à Varrone nominantur.In ripis etiam fluminum & lacuum nidos fingunt halcyones: nec Ariſtotelem latuit eas in fluuios aſcendere,ſed hyeme non occultantur. Auis eſt non multo maior paſſere. Cùm autem marinæ halcyonis corpus totùm coloribus cæruleo,uiridi,ſubpurpureo, ſed miſtis inſigne ſit, adeo ut neq; collum,nec alæ aliquo ex eis careant,& roſtrum habeat ſubuiride, longum,tenue,fluuiatilis ſeu ripariæ pectus purpureum eſt, collum & dorſum in uiridi cæruleum, alæ fuſcæ, roſtrum, ut etiam pedes, cinereum. Veſcitur piſciculis & uermibus. Lagopus quoq; in altiſſimarum Alpium ſpecubus iuxta glaciem,quæ tota nunquam æſtate ſolis calore liquefacta,uel alijs etiam anni temporibus imbre dilapſa diffunditur,nidos cõſtruit & cubat. Ex pedibus, quos habet leporis inſtar uillis & quidem candidis, non plumis, ueſtitos,nomen traxit.Ei magnitudo columbæ.Color hyeme candidus,æſtate in candido cinereus.Longe non uolat,ſed Alpibus ſe tenet. Capta nõ uiuit,nedum manſueſcit. Caro huius auis ſano palato eſt bona, ægroto ſalutaris.At aues,quibus oculi diurno ſpacio ſunt hebetes,acres,acutiq; nocturno,interdiu latere, noctu ex latebris euolare, & ad paſtum ſolent accedere, quas iccirco nocturnas appellant:quales ſunt ueſpertilio, bubo, ulula, noctua,nycticorax. Verum hæ non ſolum in tenebricoſis montium & rupium cauernis latent,ſed etiam in cauis arboribus,in ædificijs deſertis, ſub tectis domorum magnificarum & templorum & turrium,quæ raro homines ſuccedunt. Veſpertilio autem uenatur culices & muſcas, exedit pernas, aliasq; carnes ſuillas de trabibus ſuſpenſas.Cæteræ aues nocturnæ perſequũtur mures,hirundines,aues,ſcarabeos,apes,ueſpas,crabrones. Sed bubo etiam capit lepuſculos & cuniculos.Ea omnium nocturnarum auium maxima ex ſono,imò uerò gemitu,quem edit,mihi uidetur nomen inueniſſe. Caput habet magnum: corpus anſeris magnitudine,breue tamen & quaſi decurtatum ac colore uarium:roſtrum curuum,ungues aduncos,oculos grandes. Huic non multum diſſimilis eſt ulula,ſed minor: quæ item ex ululãti



uoce nomen hoc traxit. Cum his duabus cognationem habent noctuæ ſed differunt uoce. Nec enim ululant, uerũ edunt ſonum, quem Ariſtophanes κικκαβαῦ nominauit. Earum quatuor ſunt genera. Vnum, cui pluma aurium modo eminet: quod maximum eſt, & aſio uocatur. Alterũ eximij candoris in gutture & uentre, alioqui candidis & luteis maculis alternis diſtinctum. Tertium paruũ, quo, ut etiam ſequenti, aucupes uenantur aues. Quartum minus illo: quod in rupibus ſaxiſqꝫ uerſatur. Hoc, ſicut & proximum, cinereis & candidis maculis uariat, item alternis. Nycticorax autem, hoc eſt coruus nocturnus, niger eſt, ut alterius generis coruus, ſed eo plerunqꝫ minor. At ueſpertilio, quæ ex ueſpere, quo euolat, nomen hoc duxit, muri nonnihil ſimilis eſt, quare ſcite ſcripſit Varro: Factus ſum ueſpertilio, neqꝫ in muribus planè, neqꝫ in uolucribus ſum. Alas enim habet & uolat, quod ei non conuenit cum muribus: ſed animalia parit, non oua, in qua re cum uolucrum natura non congruit, & fœtus uberibus admotos lacte nutrit, cum uolucres cibos conquirant undiqꝫ, quos in os pullorum inſerant. Præterea ſunt ei dentes, quibus carent uolucres. Caput autem ſimile habet muri uel cani: aures plerunqꝫ duas, raro quatuor: dentes ſerratos: corpus obſcure fuluis pilis ueſtitum, roſtrum tamen nigrum, item aures: alas duas, quæ ut draconis & piſcis uolantis, non ex plumis conſtant, ſed ex membranis, & quidem nigris. In utraqꝫ uerò ala habet digitum, cui eſt unguis, caudam latam, & ſicut alas, membranaceam, in qua duos pedes, quorum uterqꝫ quinos habet digitos uncis unguibus armatos, quibus in parietibus & rimis cauernarum adhæreſcit. Aut enim pendet, aut uolat, aut iacet. Quia uerò pedes non oriuntur ex corpore, ſed ex cauda, ei eſſe traditur coxendix una. Vocem acutam ut mus non emittit, uerum ferè ut catellus latrat. Geminos autem, ut Plinius, uolitat amplexa infantes, ſecumq́ꝫ deportat. Cauda & alis affixa dies aliquot uiuit. Quinetiam Troglodytæ, qui in Africa habitant, interdiu, maxime uerò meridie latent in ſuis ſpecubus.

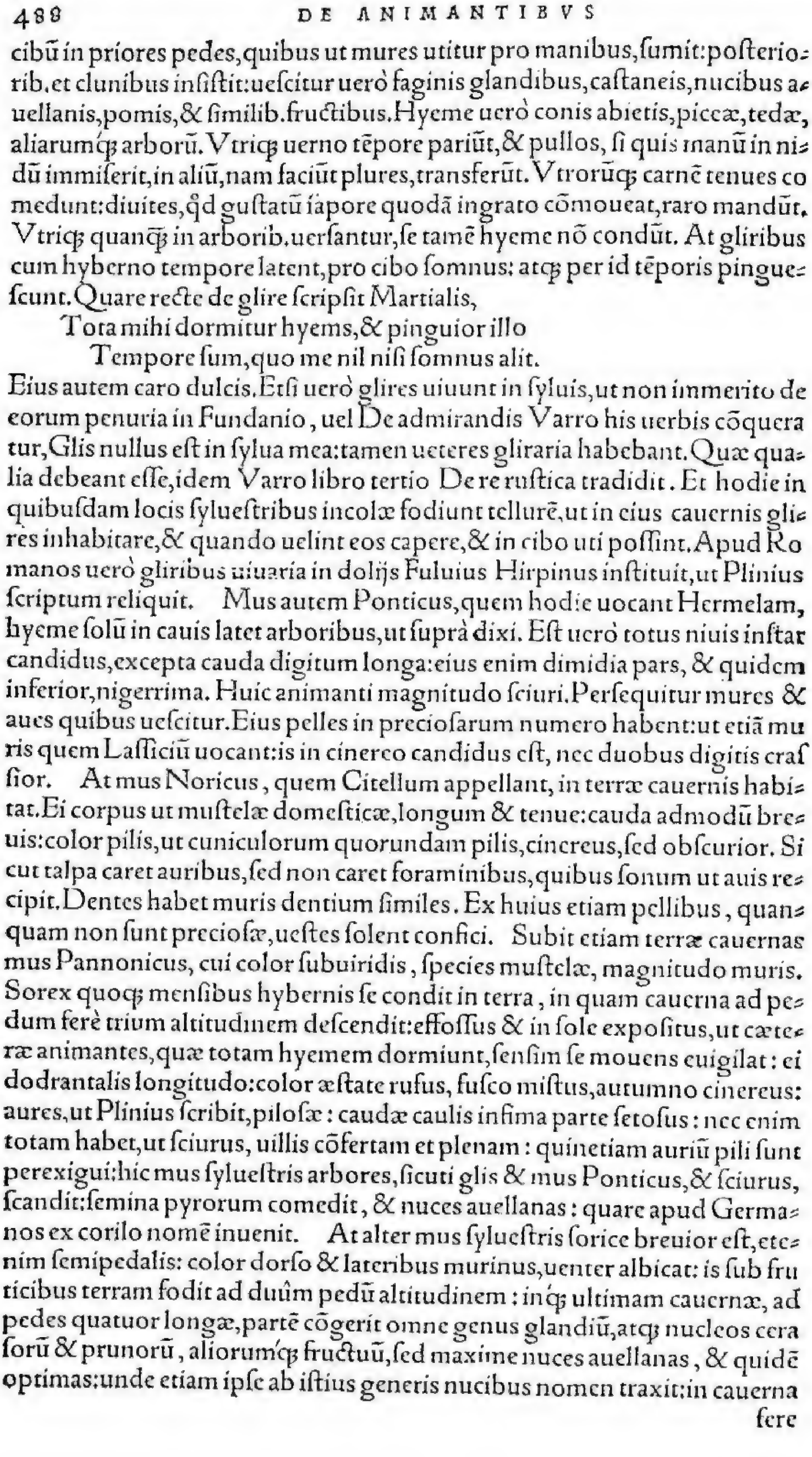
De primi generis animantibus, quæ noctu uel interdiu in terræ cauernis deliteſcunt, dormiuntúe ſatis. Abeo ad ſecundi generis animantes, quæ certo anni tempore, ut dixi, ſubterraneas cauernas ſuccedunt, & in eis graui ſomno preſſæ menſes aliquot, quaſi mortuæ ſine cibo conſumunt, ac uſqꝫ ad finem eum latent, dum tepore ueris humo excitatæ reuiuiſcunt, & reminiſcuntur cibum, quem tanto tempore oblitæ erant ſumere. Tametſi ex his de quibus iam dixi, aliquæ ſunt etiam, ut omnis generis quædam beſtiæ ſunt, in harum numero, ut ſuo loco dicã. Hæ aũt aut terrenæ ſunt, aut uolucres, aut aquatiles, aut earum uita eſt in terra pariter & in humore: ſed terrenas hic quoqꝫ primò perſequar. Itaqꝫ multæ quadrupedes hyemis aut æſtatis tempore ſe in ſpecus condunt. Etenim mures Alpini autumno ſubeunt cauernas, in quibus æſtate cubare conſueuerunt. Nam in eis ex fœno, ſtraminibus, ſarmentis exſtruunt cubilia, in quibus totam hyemem uſqꝫ ad uer erinaceorum inſtar conuoluti deliteſcunt & dormiunt. In una cauerna plerunqꝫ ſeptem, aut nouem, aut undecim, aut tredecim. Mira uerò eis machinatio & ſolertia cum fœnum ac reliqua iam congeſſerunt. Vnus enim humi ſtratus erectis pedibus omnibus iacet in dorſo, in quem, tanquã in plauſtrum



SVBTERRANEIS. 487

ſtrum quoddam, cæteri ea quæ congeſſerunt, conijciunt,& ſic onuſtum, cauda mordicus apprehēſa, in ſpecum trahunt, & quaſi quodam modo inuehunt:ex quo euenit,ut per id temporis detrito dorſo eſſe uideantur. Itaq; poſteaquam cubilia in ſpecu ſtrauerint, ipſum aditum atq; os eius ſarmentis & terra obſtruunt & obturant,ut tuti à uentorum uí, ab imbribus, à frigore eſſe poſſint. Tam autem arcte & grauiter dormiunt,ut effoſſi & extracti non excitentur antequam in ſole expoſiti uel ad ignem locati concaluerint. Hic mus cognomen ex Alpibus, in quibus naſcitur,traxit: color ei eſt aut fuſcus,aut cinereus,aut rutilus:magnitudo ferè leporis: muris ſpecies ac figura,ex qua mus dicitur. Attamen mutilas habet aures & quaſi decurtatas:priores dentes longos & acutos: caudam amplius duos palmos longā, pedes breues & uillis ſuperius refertos: digitos pedum urſinis ſimiles: ungues longos, quibus alte effodit terram: poſterioribus pedibus non ſecus ac rurſus ire ſolet, ac interdum ingredi bipes. Si cibus huic animanti datur, eum in priores pedes ſumit,ut ſciurus: ut idem ſciurus & ſimia erectus uſq; eo in clunibus reſidet quoad ipſum comederit. Veſcitur non modo fructibus,ſed etiam pane,carne,piſcibus,iure,pulmento: cupide uerò lacte,butyro,caſeo,quæ cum mādit,oris ſuctu ſonitum ſic uti porcellus edit. Multum dormit:at cum uigilat, ſemper aliquid agit, ſtramina, fœnum,linteola,ralla cubili ſuo importans: quibus os ita complet,ut nihil amplius capere poſſit: reliquum pedibus accipit & trahit. Cum irritatus exarſerit iracundia,acriter mordet. Si quando inter ſe colludunt mures Alpini, ut catelli clamorem faciunt. Cum è cauerna montiuagi egrediuntur ad paſtum, ex eis unus aliquis remanet iuxta illius aditum, quàm poteſt diligentiſſime & longiſſime proſpiciens. Is cum uel hominem,uel armentum,uel feram uiderit, ſine mora clamat:quo audito undiq; omnes ad cauernam concurrunt. Eorum autē uox fiſtulæ acutæ & lædentis aures ſimilis eſt:qua & mutationē aeris ſignificant,& ſibi quid aduerſi accidere. Dorſum ualde pingue habēt,quum cæteræ corporis partes ſint macræ: quanquam hæc uere nec pinguitudo nec caro dici poteſt:ſed, ut mammillarum caro in bubus, inter eas eſt medium quiddam. Illud ipſum utile eſt puerperis,& his quæ ex utero laborant: quibus etiā eorum prodeſt pinguitudo. Vigilias præterea tollit. Glires etiam hyeme nō ſolum in cauis arboribus,de qua re ſuprà dixi, ſed in terræ latent ſpecubus. Glirem autem Ariſtoteles ἐλειὸν nominat,cinereus, ut Albertus ſcribit eſt,excepto uentre, qui albicat. Ab eo differt beſtiola paulo minor:quam alij Græci hac de cauſa καμψίουρον uocarūt,quod uertat & ſurſum uerſus inflectat caudam: aliqui uerò σκίουρον,quòd cauda ſua uillis ueſtita & conferta,quaſi flabello corpus ſoleat inūbrare: aliqui μυῶ σκίουρον,quòd præterea ſimilitudinē quandā gerat,ſpeciemq; muris:ſicut etiam ſciurus Fennicus,qui nō cauda,nō figura & liniamētis totius corporis, nō magnitudine, nō moribus,ſed ſolo colore differt à noſtrate ſciuro: nā in candido cinereus eſt,cum ſciurus noſtras ſit aut rutilus,aut niger:attamen in ea Sarmatiæ parte,quam hodie Poloniam uocamus,inuenitur cui rutilus color miſtus cinereo. Vtriq; autem ſciuro,hoc eſt tam Fennico quàm noſtrati,duo inferiores dentes ſunt longi;uterq; cū graditur,demiſſam caudam trahit:quū ueſcitur,

S 4 cibum

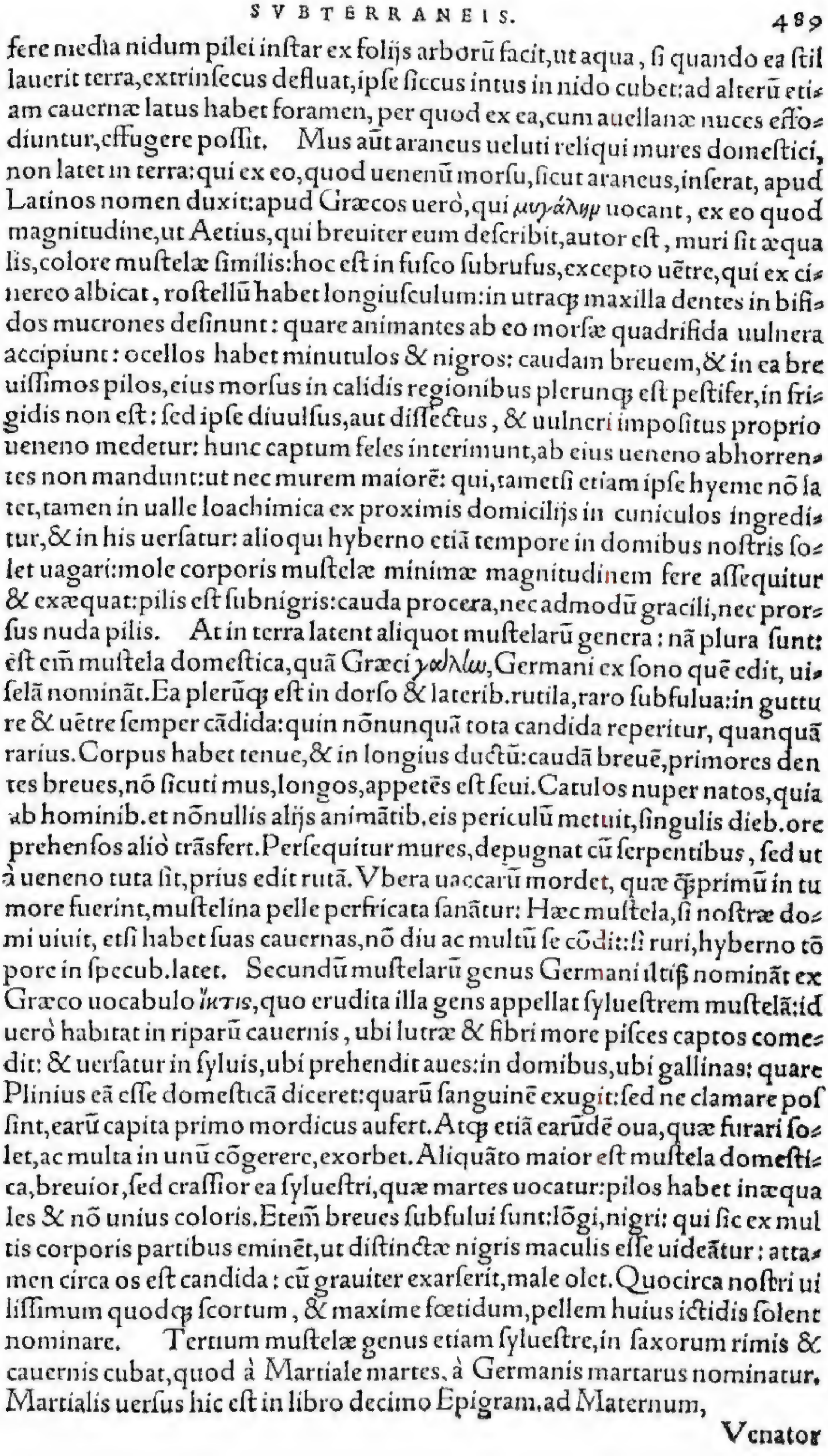


cibũ in priores pedes, quibus ut mures utitur pro manibus, ſumit: poſterioribus et clunibus inſiſtit: ueſcitur uerò faginis glandibus, caſtaneis, nucibus auellanis, pomis, & ſimilib. fructibus. Hyeme uerò conis abietis, piceæ, tedæ, aliarumq́ꝫ arborũ. Vtriqꝫ uerno tẽpore pariũt, & pullos, ſi quis manũ in nidũ immiſerit, in aliũ, nam faciũt plures, transferũt. Vtrorũqꝫ carnẽ tenues comedunt: diuites, q̄d guſtatũ ſapore quodã ingrato cõmoueat, raro mandũt. Vtriqꝫ quanq̃ꝫ in arborib. uerſantur, ſe tamẽ hyeme nõ condũt. At gliribus cum hyberno tempore latent, pro cibo ſomnus: atqꝫ per id tẽporis pingueſcunt. Quare recte de glire ſcripſit Martialis,

Tota mihi dormitur hyems, & pinguior illo
Tempore ſum, quo me nil niſi ſomnus alit.

Eius autem caro dulcis. Etſi uerò glires uiuunt in ſyluis, ut non immerito de eorum penuria in Fundanio, uel De admirandis Varro his uerbis cõqueratur, Glis nullus eſt in ſylua mea: tamen ueteres gliraria habebant. Quæ qualia debeant eſſe, idem Varro libro tertio De re ruſtica tradidit. Et hodie in quibuſdam locis ſylueſtribus incolæ fodiunt tellurẽ, ut in eius cauernis glires inhabitare, & quando uelint eos capere, & in cibo uti poſſint. Apud Romanos uerò gliribus uiuaria in dolijs Fuluius Hirpinus inſtituit, ut Plinius ſcriptum reliquit. Mus autem Ponticus, quem hodie uocant Hermelam, hyeme ſolũ in cauis latet arboribus, ut ſuprà dixi. Eſt uerò totus niuis inſtar candidus, excepta cauda digitum longa: eius enim dimidia pars, & quidem inferior, nigerrima. Huic animanti magnitudo ſciuri. Perſequitur mures & aues quibus ueſcitur. Eius pelles in precioſarum numero habent: ut etiã muris quem Laſſiciũ uocant: is in cinereo candidus eſt, nec duobus digitis craſſior. At mus Noricus, quem Citellum appellant, in terræ cauernis habitat. Ei corpus ut muſtelæ domeſticæ, longum & tenue: cauda admodũ breuis: color pilis, ut cuniculorum quorundam pilis, cinereus, ſed obſcurior. Sicut talpa caret auribus, ſed non caret foraminibus, quibus ſonum ut auis recipit. Dentes habet muris dentium ſimiles. Ex huius etiam pellibus, quanquam non ſunt precioſæ, ueſtes ſolent confici. Subit etiam terræ cauernas mus Pannonicus, cui color ſubuiridis, ſpecies muſtelæ, magnitudo muris. Sorex quoqꝫ menſibus hybernis ſe condit in terra, in quam cauerna ad pedum ferè trium altitudinem deſcendit: effoſſus & in ſole expoſitus, ut cæteræ animantes, quæ totam hyemem dormiunt, ſenſim ſe mouens euigilat: ei dodrantalis longitudo: color æſtate rufus, fuſco miſtus, autumno cinereus: aures, ut Plinius ſcribit, piloſæ: caudæ caulis infima parte ſetoſus: nec enim totam habet, ut ſciurus, uillis cõfertam et plenam: quinetiam auriũ pili ſunt perexigui: hic mus ſylueſtris arbores, ſicuti glis & mus Ponticus, & ſciurus, ſcandit: ſemina pyrorum comedit, & nuces auellanas: quare apud Germanos ex corilo nomẽ inuenit. At alter mus ſylueſtris ſorice breuior eſt, etenim ſemipedalis: color dorſo & lateribus murinus, uenter albicat: is ſub fruticibus terram fodit ad duûm pedũ altitudinem: inq́ꝫ ultimam cauernæ, ad pedes quatuor longæ, partẽ cõgerit omne genus glandiũ, atqꝫ nucleos ceraſorũ & prunorũ, aliorumq́ꝫ fructuũ, ſed maxime nuces auellanas, & quidẽ optimas: unde etiam ipſe ab iſtius generis nucibus nomen traxit: in cauerna

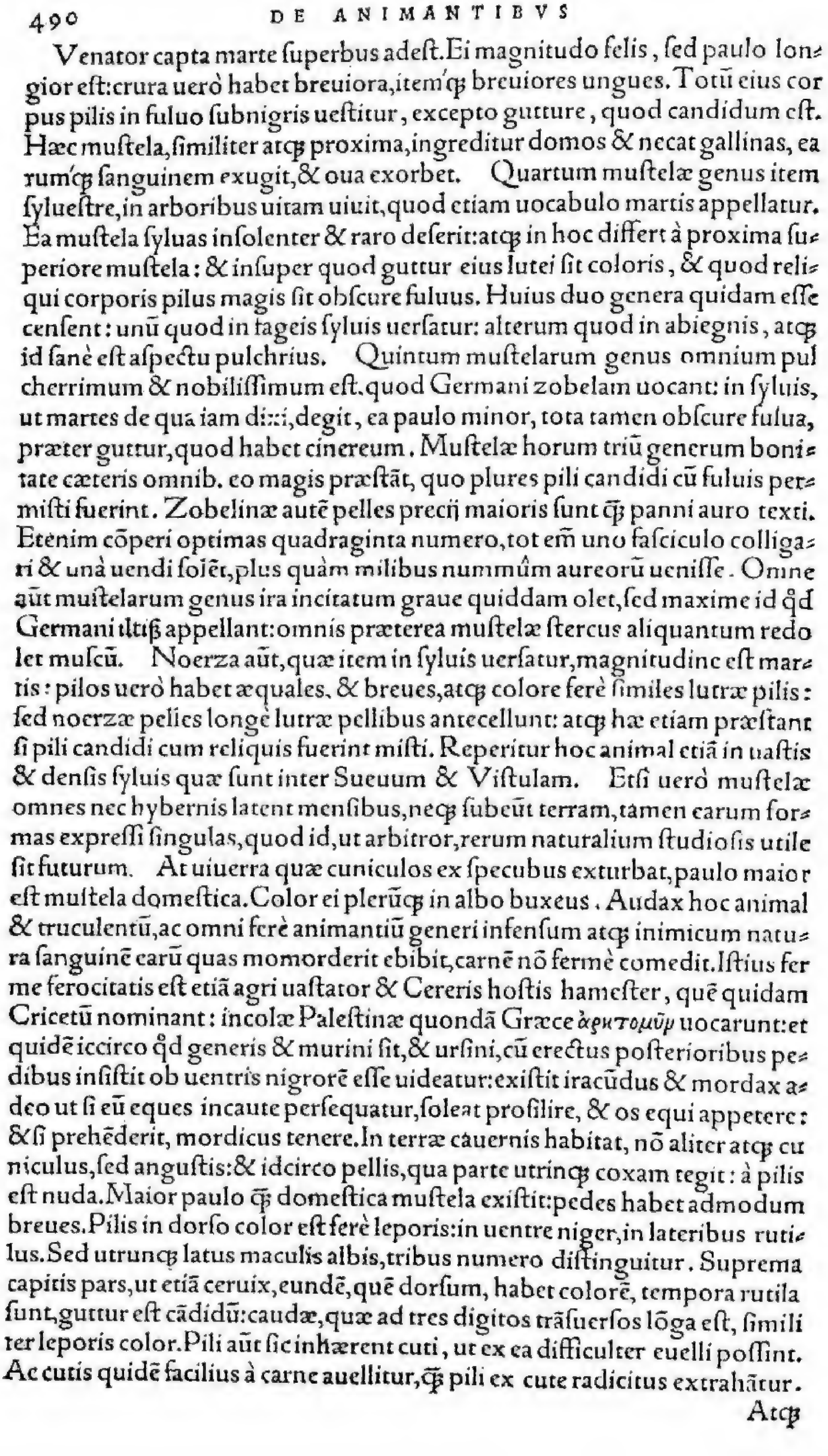
fere



SVBTERRANEIS. 489

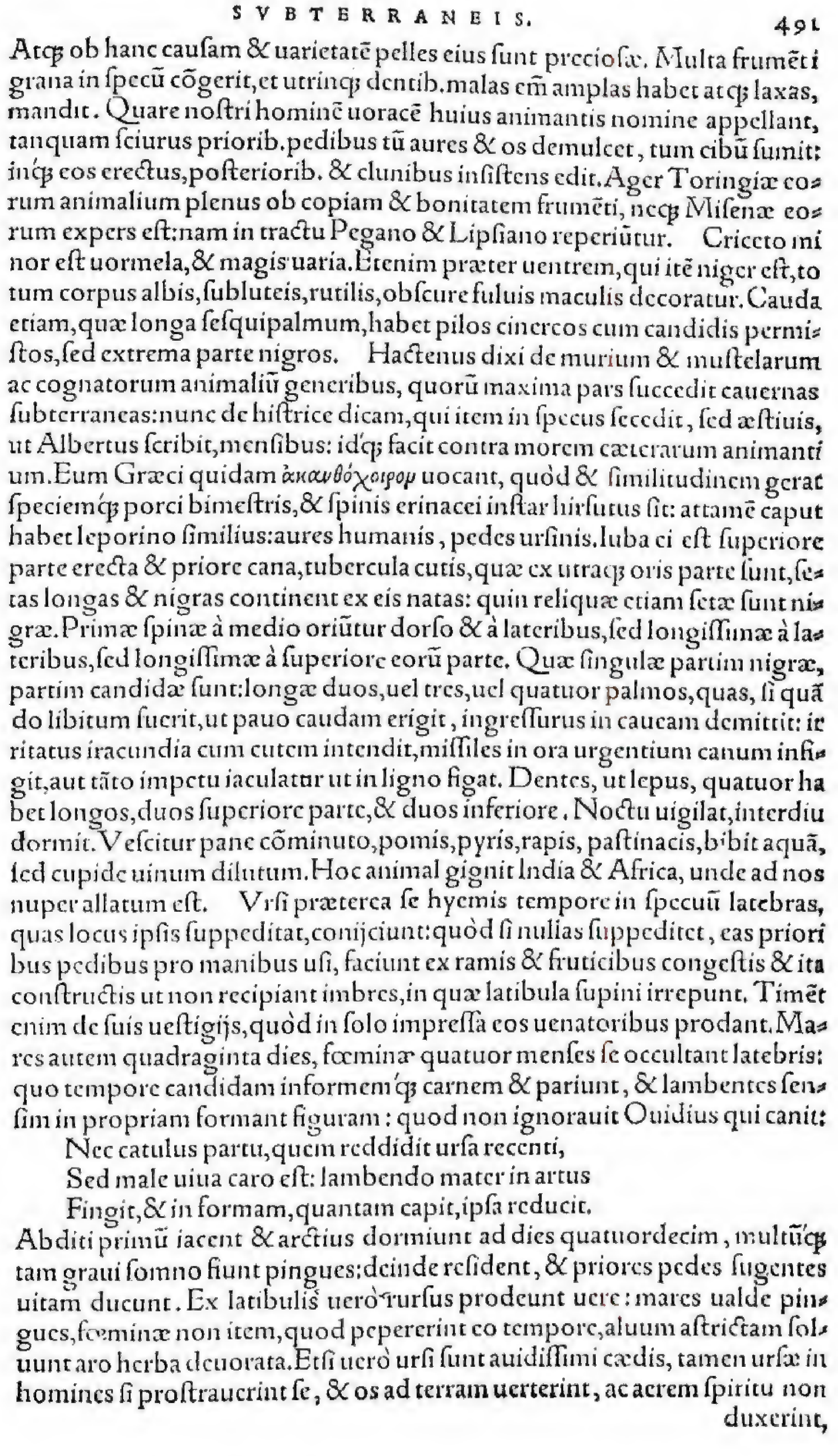
fere media nidum pilei inſtar ex folijs arborū facit,ut aqua , ſi quando ea ſtillauerit terra,extrinſecus defluat,ipſe ſiccus intus in nido cubet:ad alterū etiam cauernæ latus habet foramen, per quod ex ea,cum auellanæ nuces effodiuntur,effugere poſſit. Mus aūt araneus ueluti reliqui mures domeſtici, non latet in terra:qui ex eo,quod uenenū morſu,ſicut araneus,inſerat, apud Latinos nomen duxit:apud Græcos uerò,qui μυγάλην uocant , ex eo quod magnitudine,ut Aetius,qui breuiter eum deſcribit,autor eſt , muri ſit æqualis,colore muſtelæ ſimilis:hoc eſt in fuſco ſubrufus,excepto uētre,qui ex cinereo albicat , roſtellū habet longiuſculum:in utraq; maxilla dentes in bifidos mucrones deſinunt : quare animantes ab eo morſæ quadrifida uulnera accipiunt : ocellos habet minutulos & nigros: caudam breuem,& in ea breuiſſimos pilos,eius morſus in calidis regionibus plerunq; eſt peſtifer,in frigidis non eſt : ſed ipſe diuulſus,aut diſſectus , & uulneri impoſitus proprio ueneno medetur: hunc captum feles interimunt,ab eius ueneno abhorrentes non mandunt:ut nec murem maiorē: qui,tametſi etiam ipſe hyeme nō latet,tamen in ualle Ioachimica ex proximis domicilijs in cuniculos ingreditur,& in his uerſatur: alioqui hyberno etiā tempore in domibus noſtris ſolet uagari:mole corporis muſtelæ minimæ magnitudinem fere aſſequitur & exæquat:pilis eſt ſubnigris:cauda procera,nec admodū gracili,nec prorſus nuda pilis. At in terra latent aliquot muſtelarū genera : nā plura ſunt: èſt enī muſtela domeſtica,quā Græci γαλῆν,Germani ex ſono quē edit, uiſelā nominānt.Ea plerūq; eſt in dorſo & laterib.rutila,raro ſubfulua:in gutture & uētre ſemper cādida:quin nōnunquā tota candida reperitur, quanquā rarius.Corpus habet tenue,& in longius ductū:caudā breuē,primores dentes breues,nō ſicuti mus,longos,appetēs eſt ſeui.Catulos nuper natos,quia ab hominib.et nōnullis alijs animātib.eis periculū metuit,ſingulis dieb.ore prehenſos aliò trāsfert.Perſequitur mures,depugnat cū ſerpentibus , ſed ut à ueneno tuta ſit,prius edit rutā.Vbera uaccarū mordet, quæ q̃ primū in tumore fuerint,muſtelina pelle perfricata ſanātur: Hæc muſtela,ſi noſtræ domi uiuit, etſi habet ſuas cauernas,nō diu ac multū ſe cōdit:ſi ruri,hyberno tōpore in ſpecub.latet. Secundū muſtelarū genus Germani iltiß nominānt ex Græco uocabulo ἴκτις,quo erudita illa gens appellat ſylueſtrem muſtelā:id uerò habitat in riparū cauernis , ubi lutræ & fibri more piſces captos comedit: & uerſatur in ſyluis,ubi prehendit aues:in domibus,ubi gallinas: quare Plinius eā eſſe domeſticā diceret:quarū ſanguinē exugit:ſed ne clamare poſſint,earū capita primo mordicus aufert.Atq; etiā earūdē oua,quæ furari ſolet,ac multa in unū cōgerere,exorbet.Aliquāto maior eſt muſtela domeſtica,breuior,ſed craſſior ea ſylueſtri,quæ martes uocatur:pilos habet inæquales & nō unius coloris.Etenī breues ſubfului ſunt:lōgi,nigri: qui ſic ex multis corporis partibus eminēt,ut diſtinctæ nigris maculis eſſe uideātur : attamen circa os eſt candida : cū grauiter exarſerit,male olet.Quocirca noſtri uiliſſimum quodq; ſcortum , & maxime fœtidum,pellem huius ictidis ſolent nominare. Tertium muſtelæ genus etiam ſylueſtre,in ſaxorum rimis & cauernis cubat,quod à Martiale martes, à Germanis martarus nominatur. Martialis uerſus hic eſt in libro decimo Epigram.ad Maternum,

Venator



Venator capta marte ſuperbus adeſt. Ei magnitudo felis, ſed paulo longior eſt: crura uerò habet breuiora, itemq́; breuiores ungues. Totū eius corpus pilis in fuluo ſubnigris ueſtitur, excepto gutture, quod candidum eſt. Hæc muſtela, ſimiliter atq; proxima, ingreditur domos & necat gallinas, earumq́; ſanguinem exugit, & oua exorbet. Quartum muſtelæ genus item ſylueſtre, in arboribus uitam uiuit, quod etiam uocabulo martis appellatur. Ea muſtela ſyluas inſolenter & raro deſerit: atq; in hoc differt à proxima ſuperiore muſtela: & inſuper quod guttur eius lutei ſit coloris, & quod reliqui corporis pilus magis ſit obſcure fuluus. Huius duo genera quidam eſſe cenſent: unū quod in fageis ſyluis uerſatur: alterum quod in abiegnis, atq; id ſanè eſt aſpectu pulchrius. Quintum muſtelarum genus omnium pulcherrimum & nobiliſſimum eſt, quod Germani zobelam uocant: in ſyluis, ut martes de qua iam dixi, degit, ea paulo minor, tota tamen obſcure fulua, præter guttur, quod habet cinereum. Muſtelæ horum triū generum bonitate cæteris omnib. eo magis præſtāt, quo plures pili candidi cū fuluis permiſti fuerint. Zobelinæ autē pelles precij maioris ſunt q̃; panni auro texti. Etenim cōperi optimas quadraginta numero, tot enī uno faſciculo colligari & unà uendi ſolēt, plus quàm milibus nummûm aureorū ueniſſe. Omne aūt muſtelarum genus ira incitatum graue quiddam olet, ſed maxime id q̊d Germani iltiß appellant: omnis præterea muſtelæ ſtercus aliquantum redolet muſcū. Noerza aūt, quæ item in ſyluis uerſatur, magnitudine eſt martis: pilos uerò habet æquales, & breues, atq; colore ferè ſimiles lutræ pilis: ſed noerzæ pelles longè lutræ pellibus antecellunt: atq; hæ etiam præſtant ſi pili candidi cum reliquis fuerint miſti. Reperitur hoc animal etiā in uaſtis & denſis ſyluis quæ ſunt inter Sueuum & Viſtulam. Etſi uerò muſtelæ omnes nec hybernis latent menſibus, neq; ſubeūt terram, tamen earum formas expreſſi ſingulas, quod id, ut arbitror, rerum naturalium ſtudioſis utile ſit futurum. At uiuerra quæ cuniculos ex ſpecubus exturbat, paulo maior eſt muſtela domeſtica. Color ei plerūq; in albo buxeus. Audax hoc animal & truculentū, ac omni ferè animantiū generi infenſum atq; inimicum natura ſanguinē earū quas momorderit ebibit, carnē nō fermè comedit. Iſtius ferme ferocitatis eſt etiā agri uaſtator & Cereris hoſtis hameſter, quē quidam Cricetū nominant: incolæ Paleſtinæ quondā Græce ἀρκτομῦν uocarunt: et quidē iccirco q̊d generis & murini ſit, & urſini, cū erectus poſterioribus pedibus inſiſtit ob uentris nigrorē eſſe uideatur: exiſtit iracūdus & mordax adeo ut ſi eū eques incaute perſequatur, ſoleat proſilire, & os equi appetere: & ſi prehēderit, mordicus tenere. In terræ cauernis habitat, nō aliter atq; cuniculus, ſed anguſtis: & idcirco pellis, qua parte utrinq; coxam tegit: à pilis eſt nuda. Maior paulo q̃; domeſtica muſtela exiſtit: pedes habet admodum breues. Pilis in dorſo color eſt ferè leporis: in uentre niger, in lateribus rutilus. Sed utrunq; latus maculis albis, tribus numero diſtinguitur. Suprema capitis pars, ut etiā ceruix, eundē, quē dorſum, habet colorē, tempora rutila ſunt, guttur eſt cādidū: caudæ, quæ ad tres digitos trāſuerſos lōga eſt, similiter leporis color. Pili aūt ſic inhærent cuti, ut ex ea difficulter euelli poſſint. Ac cutis quidē facilius à carne auellitur, q̃; pili ex cute radicitus extrahātur.

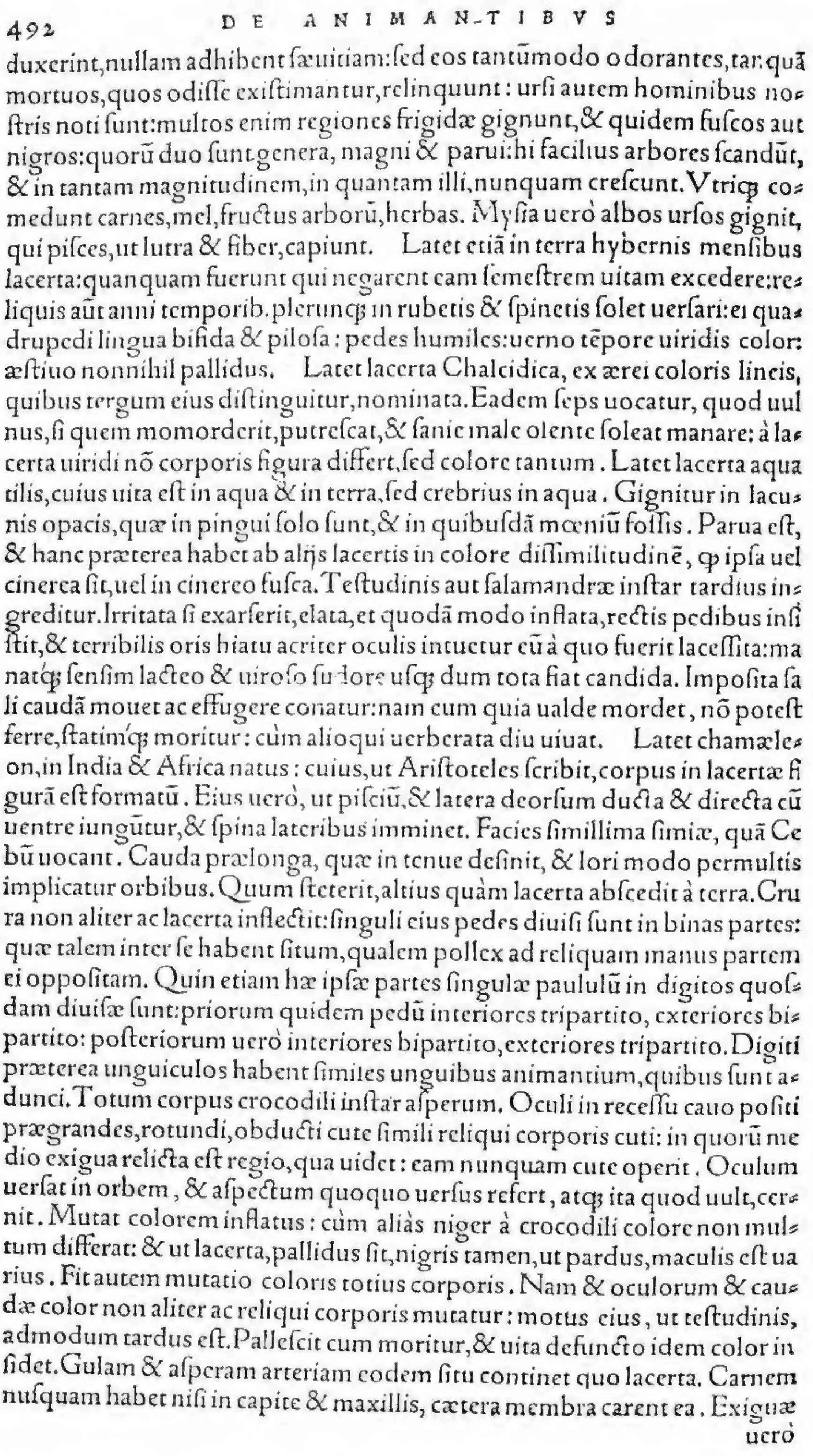
Atq;



Atq; ob hanc cauſam & uarietatẽ pelles eius ſunt precioſæ. Multa frumẽti grana in ſpecũ cõgerit, et utrinq; dentib. malas em̃ amplas habet atq; laxas, mandit. Quare noſtri hominẽ uoracẽ huius animantis nomine appellant, tanquam ſciurus priorib. pedibus tũ aures & os demulcet, tum cibũ ſumit: inq; eos erectus, poſteriorib. & clunibus inſiſtens edit. Ager Toringiæ eorum animalium plenus ob copiam & bonitatem frumẽti, neq; Miſenæ eorum expers eſt: nam in tractu Pegano & Lipſiano reperiũtur. Cricceto minor eſt uormela, & magis uaria. Etenim præter uentrem, qui itẽ niger eſt, totum corpus albis, ſubluteis, rutilis, obſcure fuluis maculis decoratur. Cauda etiam, quæ longa ſeſquipalmum, habet pilos cinereos cum candidis permiſtos, ſed extrema parte nigros. Hactenus dixi de murium & muſtelarum ac cognatorum animaliũ generibus, quorũ maxima pars ſuccedit cauernas ſubterraneas: nunc de hiſtrice dicam, qui item in ſpecus ſecedit, ſed æſtiuis, ut Albertus ſcribit, menſibus: idq; facit contra morem cæterarum animantium. Eum Græci quidam ἀκανθόχοιρον uocant, quòd & ſimilitudinem gerat ſpeciemq; porci bimeſtris, & ſpinis erinacei inſtar hirſutus ſit: attamẽ caput habet leporino ſimilius: aures humanis, pedes urſinis. Iuba ei eſt ſuperiore parte erecta & priore cana, tubercula cutis, quæ ex utraq; oris parte ſunt, ſetas longas & nigras continent ex eis natas: quin reliquæ etiam ſetæ ſunt nigræ. Primæ ſpinæ à medio oriũtur dorſo & à lateribus, ſed longiſſimæ à lateribus, ſed longiſſimæ à ſuperiore eorũ parte. Quæ ſingulæ partim nigræ, partim candidæ ſunt: longæ duos, uel tres, uel quatuor palmos, quas, ſi quãdo libitum fuerit, ut pauo caudam erigit, ingreſſurus in caueam demittit: irritatus iracundia cum cutem intendit, miſſiles in ora urgentium canum infigit, aut tãto impetu iaculatur ut in ligno figat. Dentes, ut lepus, quatuor habet longos, duos ſuperiore parte, & duos inferiore. Noctu uigilat, interdiu dormit. Veſcitur pane cõminuto, pomis, pyris, rapis, paſtinacis, bibit aquã, ſed cupide uinum dilutum. Hoc animal gignit India & Africa, unde ad nos nuper allatum eſt. Vrſi præterea ſe hyemis tempore in ſpecuũ latebras, quas locus ipſis ſuppeditat, conijciunt: quòd ſi nullas ſuppeditet, eas prioribus pedibus pro manibus uſi, faciunt ex ramis & fruticibus congeſtis & ita conſtructis ut non recipiant imbres, in quæ latibula ſupini irrepunt. Timẽt enim de ſuis ueſtigijs, quòd in ſolo impreſſa eos uenatoribus prodant. Mares autem quadraginta dies, fœminæ quatuor menſes ſe occultant latebris: quo tempore candidam informemq; carnem & pariunt, & lambentes ſenſim in propriam formant figuram: quod non ignorauit Ouidius qui canit:

Nec catulus partu, quem reddidit urſa recenti,
Sed male uiua caro eſt: lambendo mater in artus
Fingit, & in formam, quantam capit, ipſa reducit.

Abditi primũ iacent & arctius dormiunt ad dies quatuordecim, multũq; tam graui ſomno fiunt pingues: deinde reſident, & priores pedes ſugentes uitam ducunt. Ex latibulis uerò rurſus prodeunt uere: mares ualde pingues, fœminæ non item, quod pepererint eo tempore, aluum aſtrictam ſoluunt aro herba deuorata. Etſi uerò urſi ſunt auidiſſimi cædis, tamen urſæ in homines ſi proſtrauerint ſe, & os ad terram uerterint, ac aerem ſpiritu non duxerint,



duxerint,nullam adhibent ſæuitiam:ſed eos tantūmodo odorantes,tanquā mortuos,quos odiſſe exiſtimantur,relinquunt : urſi autem hominibus noſtris noti ſunt:multos enim regiones frigidæ gignunt,& quidem fuſcos aut nigros:quorū duo ſunt genera, magni & parui:hi facilius arbores ſcandūt, & in tantam magnitudinem,in quantam illi,nunquam creſcunt. Vtriqꝫ comedunt carnes,mel,fructus arborū,herbas. Myſia uerò albos urſos gignit, qui piſces,ut lutra & fiber,capiunt. Latet etiā in terra hybernis menſibus lacerta:quanquam fuerunt qui negarent eam ſemeſtrem uitam excedere:reliquis aūt anni temporib. plerunqꝫ in rubetis & ſpinetis ſolet uerſari:ei quadrupedi lingua bifida & piloſa : pedes humiles:uerno tēpore uiridis color: æſtiuo nonnihil pallidus. Latet lacerta Chalcidica, ex ærei coloris lineis, quibus tergum eius diſtinguitur,nominata. Eadem ſeps uocatur, quod uulnus,ſi quem momorderit,putreſcat,& ſanie male olente ſoleat manare: à lacerta uiridi nō corporis figura differt,ſed colore tantum . Latet lacerta aquatilis,cuius uita eſt in aqua & in terra,ſed crebrius in aqua . Gignitur in lacunis opacis,quæ in pingui ſolo ſunt,& in quibuſdā mœniū foſſis . Parua eſt, & hanc præterea habet ab alijs lacertis in colore diſſimilitudinē, ꝙ ipſa uel cinerea ſit,uel in cinereo fuſca. Teſtudinis aut ſalamandræ inſtar tardius ingreditur. Irritata ſi exarſerit,elata,et quodā modo inflata,rectis pedibus inſiſtit,& terribilis oris hiatu acriter oculis intuetur cū à quo fuerit laceſſita:manatqꝫ ſenſim lacteo & uiroſo ſudore uſqꝫ dum tota fiat candida. Impoſita ſali caudā mouet ac effugere conatur:nam cum quia ualde mordet, nō poteſt ferre,ſtatimqꝫ moritur : cùm alioqui uerberata diu uiuat. Latet chamæleon,in India & Africa natus : cuius,ut Ariſtoteles ſcribit,corpus in lacertæ figurā eſt formatū . Eius uerò, ut piſciū,& latera deorſum ducta & directa cū uentre iungūtur,& ſpina lateribus imminet. Facies ſimillima ſimiæ, quā Cebū uocant . Cauda prælonga, quæ in tenue deſinit, & lori modo permultis implicatur orbibus. Quum ſteterit,altius quàm lacerta abſcedit à terra. Crura non aliter ac lacerta inflectit:ſinguli eius pedes diuiſi ſunt in binas partes: quæ talem inter ſe habent ſitum,qualem pollex ad reliquam manus partem ei oppoſitam. Quin etiam hæ ipſæ partes ſingulæ paululū in digitos quoſdam diuiſæ ſunt:priorum quidem pedū interiores tripartito, exteriores bipartito: poſteriorum uerò interiores bipartito,exteriores tripartito. Digiti præterea unguiculos habent ſimiles unguibus animantium,quibus ſunt adunci. Totum corpus crocodili inſtar aſperum. Oculi in receſſu cauo poſiti prægrandes,rotundi,obducti cute ſimili reliqui corporis cuti: in quorū medio exigua relicta eſt regio,qua uidet : eam nunquam cute operit . Oculum uerſat in orbem , & aſpectum quoquo uerſus refert , atqꝫ ita quod uult,cernit . Mutat colorem inflatus : cùm aliàs niger à crocodili colore non multum differat: & ut lacerta,pallidus fit,nigris tamen,ut pardus,maculis eſt uarius . Fit autem mutatio coloris totius corporis . Nam & oculorum & caudæ color non aliter ac reliqui corporis mutatur : motus eius , ut teſtudinis, admodum tardus eſt. Palleſcit cum moritur,& uita defuncto idem color inſidet. Gulam & aſperam arteriam eodem ſitu continet quo lacerta. Carnem nuſquam habet niſi in capite & maxillis, cætera membra carent ea . Exiguæ

uerò

uerò carũculæ ſunt maxillis & caudæ,qua parte corpori eſt agnata. Sanguinem tantũmodo habet in corde,in oculis,in loco cordis ſuperiore, & in uenis hinc ductis:atq; in his quidem perpaucum. Cerebrum paululum ſupra oculos poſitum, & cum eis continens eſt. Cute autem oculorum exteriore detracta cõplectitur quiddam quod uelut annulus æneus tenuis pellucet. Membranæ multæ ac robuſtæ & quæ multo præſtãt his quæ cæteris ſunt, diſtribuuntur in totũ eius corpus. Totus diſſectus diu ſpirat,quòd exiguus admodũ motus adhuc in ipſius inſit corde. Cum omnes corporis partes cõtrahit,tũ uel maxime coſtas. Lienẽ qui cõſpici poſſit,nuſquã continet. Aura uerò perhibetur ali:unde Ouidius non modo dulcis,ſed etiã doctus poeta:

Id quoq; quod uentis animal nutritur & aura,
Protinus aſſimilat, tetigit quoſcunq; colores.

Stellio etiam latet,figura ſimilis eſt lacertæ, natura chamæleonti: nam rore tantũ uiuit,& præterea araneis & melle. Eum Nicander ἀσκάλαβον, Ariſtoteles ἀσκαλαβώτην nominat. Etenim illius tergũ guttis ſtellarũ inſtar lucentibus pictũ:ex qua re etiam apud Latinos nomẽ inuenit: atq; hoc differt à lacerta. Idem γαλεώτης à Græcis uocatur. Vt anguis exuit uere membranã hybernam tanquam ſenectutem: eamq́; niſi præripiatur,deuorat. Quem momorderit ſtellio,ſtupor opprimit. In Græcia eſt uenenatus & peſtifer,in Sicilia innocens. Aduerſatur ſcorpionibus:uitam agit in ſepulchris, in cameris,in locis oſtiorum & feneſtrarum:incluſus in uitro uitam ſine ullo cibo ſupra ſemeſtre ſpacium ducere poteſt:eius oculi tantũmodo intumeſcunt, mali præterea nihil tum patitur.

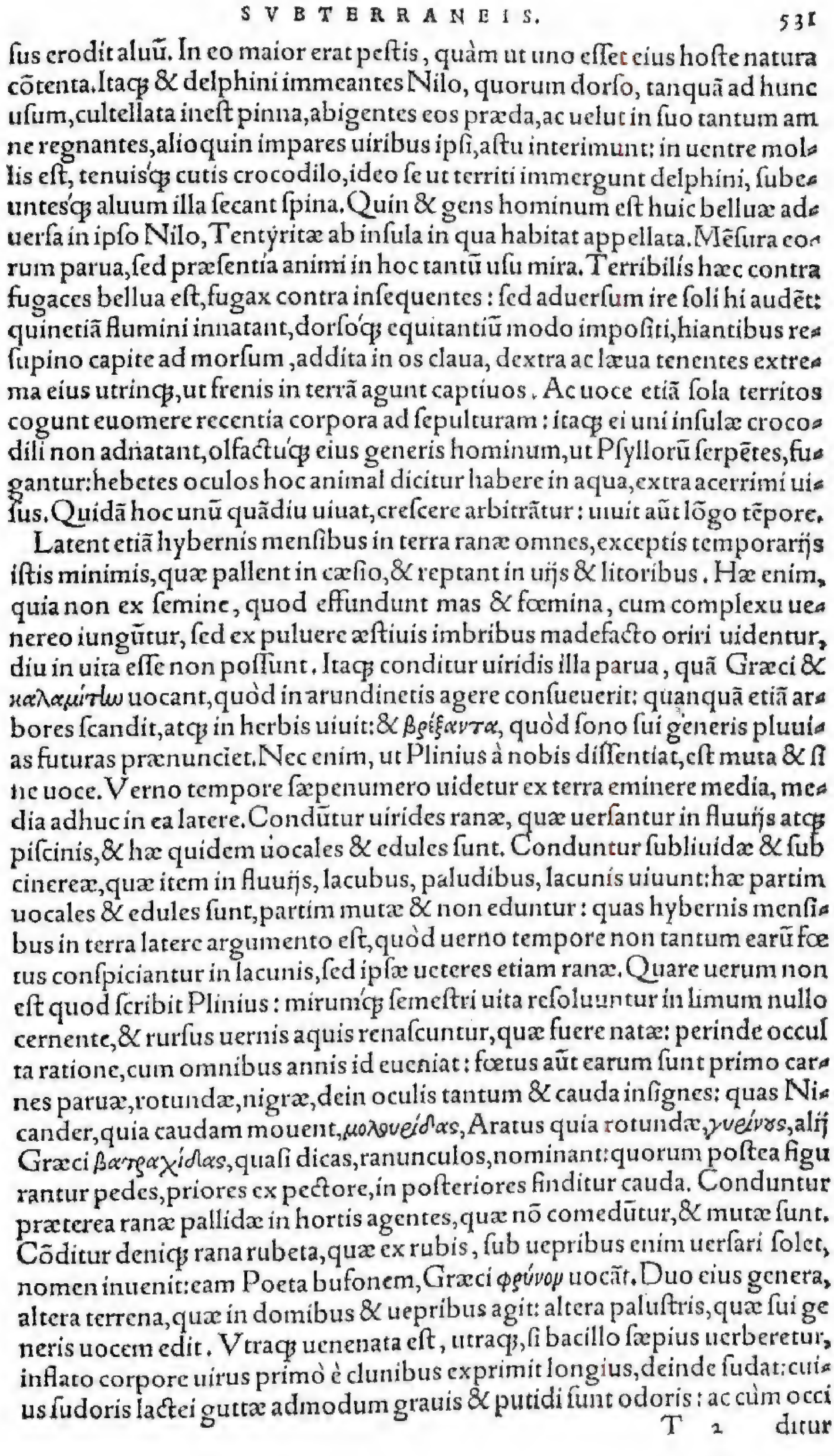
Latet præterea hybernis menſibus ſalamandra. Etenim hoc anno in Februario Snebergi maxima uis ſalamandrarũ ex uicinis locis collecta, agglomerataq́; in ultimã cuniculi cuiuſdam, quondam in Molebergum montem acti,tunc uerò inſtaurati,parte fuit reperta. Et proximo anno in Nouembri ſalamandra uiua ex fonte finitimæ ſyluæ per fiſtulas in hoc oppidũ influxit. Pluuiæ aũt & ſubſequens ſerenitas ſalamandras excitant ex uenis, uenulis, cõmiſſuriſq; ſaxorũ: hanc quadrupedem,cui item lacertæ figura,Germani, quia propter crura breuia tarde graditur,Græco nomine μόλγην appellant. Caput ei magnum,uenter lutei coloris,ut etiã ima caudæ pars: reliquũ corpus totum alternis maculis nigris & luteis quaſi ſtellatum diſtinguitur. Propter frigus ignem,non aliter ac glacies,extinguit:quo modo etiã oua ſerpentium in ignẽ camini coniecta,flãmam ſolẽt extinguere: attamẽ tam ipſa oua quàm ſalamandra cõburuntur. Salamandra aũt irritata ſaniẽ euomit lacteã: huic animali nec maſculinum nec fœmininũ genus falſo putant eſſe. Teſtudo etiam terreſtris totã hyemem in terra latet, atq; graui ſomno preſſa tempus ſine ullo cibo traducit. Scarabei deniq; rutili,& grylli, qui potiſſimũ noctu ſtrident,aridam fodiũt terram,ut in eius cauernis cubent æſtate: grylli domeſtici etiam hyeme. Nam ſcarabei ante autumnũ,imò prius intereunt quã tota æſtas effluxerit:grylli agreſtes ante hyemem, ut etiam aranei nigri, qui ſimiliter habitant in terræ rimis. At ſcolopendra in truncis arborum, aut in lignis ſupra terram locatis,aut in palis terræ infixis,unde nomen inuenit,cùm putreſcunt,& gignitur & uiuit:quibus amotis aut cõmotis egrediT tur:

tur:aliàs plerunq; ſolet latere. Pennis caret,ſed plurimos habet pedes:quocirca eam ex Latinis alij multipedā, alij centipedam, alij millipedā uocarūt: ſi quando repit, partem corporis mediā tanquam arcum intendit: ſi bacillo aliáue re tangitur,ſe contrahit.Color ei æneus,corpus tenue,nec ualde latū, longū uerò tres digitos,aut ſummū quatuor. Iam in uolucrib. quæ ſe condunt,hirundines ripariæ ſunt. Etem̄ plures numero inter ſe nexæ hybernis menſibus latēt in ripis fluminū, lacuū, paludum, & in litoribus ac ſcopulis maris;unde accidit, ut piſcatores interdū ita inter ſe iunctas ex aquis extrahant.Dictæ autem ſunt ripariæ,quòd ſoleant ripas excauare,& in eis nidos cōſtruere ac latere:has Græci & ἄποδας uocant,nō q̊d ſine pedibus ſint,ſed eorū careant uſu;& κυψέλους,quòd oua pariāt et excubent in ciſtellis longis, ex luto fictis: quibus aditus ſit anguſtus, ut omni anni tempore belluas & homines uitare,hyeme à frigoribus tutæ eſſe poſſint. Hoc differūt ab hirundinib.tam agreſtibus q̄ domeſticis,quòd tibias habeāt hirſutas.Hæ,inquit Plinius,ſunt quæ toto mari cernūtur,nec unquā tam longo naues,tamq́; cōtinuo curſu recedūt à terra,ut non circumuolitent eas apodes. Cætera genera reſidunt & inſiſtunt,his quies,niſi in nido nulla:aut pendent,aut iacent.

Hyeme etiā in cauernis montium, etſi non in his ſolis, latent ueſpertiliones,bubones,ululæ,noctuæ, hirundines,ſturni,palumbes, turtures, merulæ,turdi,alaudæ,upupæ:de qua re ſuprà dixi.

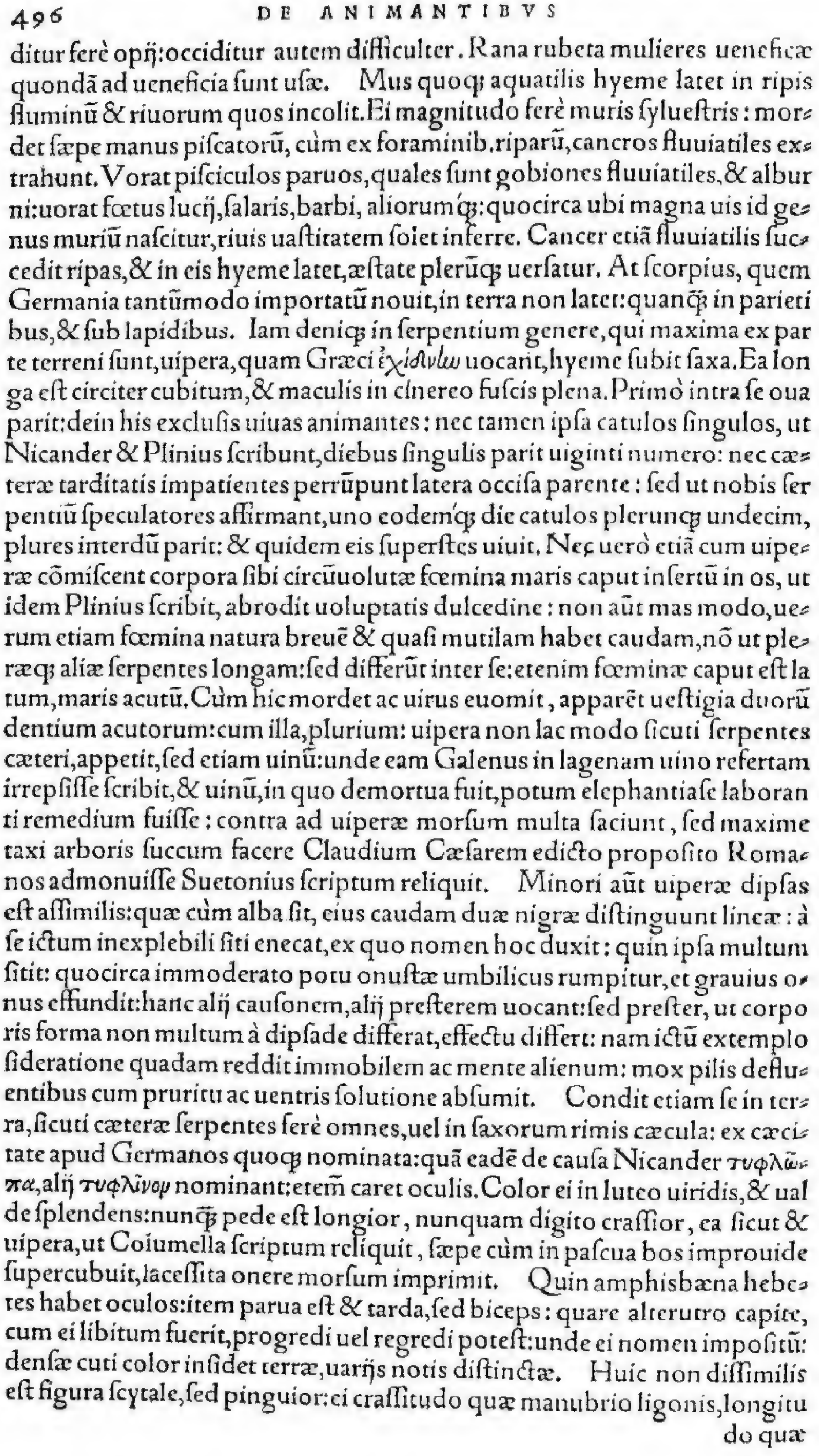
Iam ex aquatiliū quæ latent genere,quædam hyeme,quædam æſtate cōdunt ſe,uel in cœno,uel in arena:& ita quidē ſe in ijs condūt,ut reliquū corpus totū tegatur,os ſit liberū. Hybernis menſibus hi piſces condunt ſe, primadiæ,hippurus,coracinus,murena,orphus,conger,turdus,merula,perca, thynnus,raia,& omne genus cartilagineū,cochleæ. Æſtiuis uerò menſibus condit ſe glaucus, aſellus, aurata. Tricenis diebus circa canis ortū purpura, buccinū,pectē,delphinus. Iam in numero animantiū, quarū uita eſt in terra pariter & in humore latet hyeme lacerta aquatilis,de qua ſuprà dixi. Crocodilus q̊q; ſpecū eiuſdē hyemis uitandæ cauſa ſuccedit, & in eo quatuor latet menſes.Frigus adeò moleſte patitur,ut etiam,cùm nō ſoleat latere,interdiu in terra uerſetur, in aqua noctu.Viuus in Europam raro nunc affertur: ſed mortuum ſæpe pharmacopolæ in officinis ſuis de trabe ſuſpendunt.Plinius eius figuram & naturā diligenter eſt perſecutus: quadrupes malū, inquit,& terra pariter ac flumine infeſtum. Vnū hoc animal terreſtre linguæ uſu caret: unum ſuperiore mobili maxilla imprimit morſum, aliàs terribile pectinatim ſtipante ſe dentiū ſerie.Magnitudine excedit plerunq; duodeuiginti cubita. Parit oua quanta anſeres,eáq; extra eum locū ſemper incubat prædiuinatione quadā, ad quem ſummo auctu eo anno egreſſurus eſt Nilus.Nec aliud animal ex minori origine in maiorē creſcit magnitudinem.Et unguibus hic armatus eſt,& contra omnes ictus cute inuicta. Hūc ſaturum cibo piſcium & ſemper eſculento ore in litore ſomno datū, parua auis,quæ trochilos ibi uocatur, rex auium in Italia,inuitat ad hiandum pabuli ſui gratia,os primo eius adſultim repurgans,mox dentes,& intus fauces quoq;,ad hanc ſcabendi dulcedinem quàm maxime hiantes: in qua uoluptate ſomno preſſum conſpicatus ichneumon,per eaſdem fauces,ut telū aliquod,immiſ-

ſus erodit

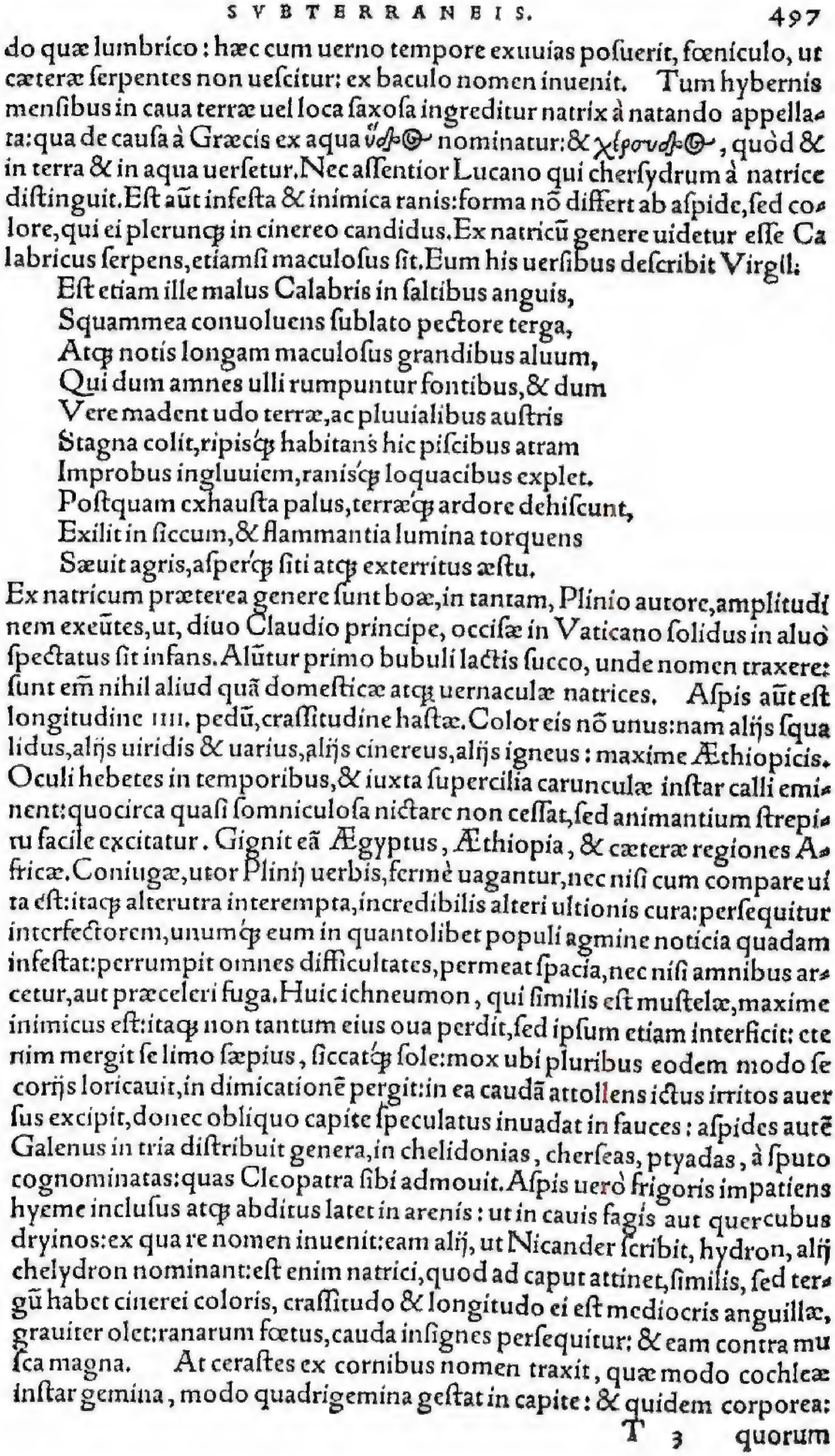


ſus erodit aluũ. In eo maior erat peſtis, quàm ut uno eſſet eius hoſte natura cõtenta. Itaq; & delphini immeantes Nilo, quorum dorſo, tanquã ad hunc uſum, cultellata ineſt pinna, abigentes eos præda, ac uelut in ſuo tantum amne regnantes, alioquin impares uiribus ipſi, aſtu interimunt: in uentre mollis eſt, tenuiſq; cutis crocodilo, ideo ſe ut territi immergunt delphini, ſubeunteſq; aluum illa ſecant ſpina. Quin & gens hominum eſt huic belluæ aduerſa in ipſo Nilo, Tentyritæ ab inſula in qua habitat appellata. Mẽſura eorum parua, ſed præſentia animi in hoc tantũ uſu mira. Terribilis hæc contra fugaces bellua eſt, fugax contra inſequentes: ſed aduerſum ire ſoli hi audẽt: quinetiã flumini innatant, dorſoq; equitantiũ modo impoſiti, hiantibus reſupino capite ad morſum, addita in os claua, dextra ac læua tenentes extrema eius utrinq;, ut frenis in terrã agunt captiuos. Ac uoce etiã ſola territos cogunt euomere recentia corpora ad ſepulturam: itaq; ei uni inſulæ crocodili non adnatant, olfactuq; eius generis hominum, ut Pſyllorũ ſerpẽtes, fugantur: hebetes oculos hoc animal dicitur habere in aqua, extra acerrimi uiſus. Quidã hoc unũ quãdiu uiuat, creſcere arbitrãtur: uiuit aũt lõgo tẽpore.

Latent etiã hybernis menſibus in terra ranæ omnes, exceptis temporarijs iſtis minimis, quæ pallent in cæſio, & reptant in uijs & litoribus. Hæ enim, quia non ex ſemine, quod effundunt mas & fœmina, cum complexu uenereo iungũtur, ſed ex puluere æſtiuis imbribus madefacto oriri uidentur, diu in uita eſſe non poſſunt. Itaq; conditur uiridis illa parua, quã Græci & *καλαμίτην* uocant, quòd in arundinetis agere conſueuerit: quanquã etiã arbores ſcandit, atq; in herbis uiuit: & *βρέξαντα*, quòd ſono ſui generis pluuias futuras prænunciet. Nec enim, ut Plinius à nobis diſſentiat, eſt muta & ſine uoce. Verno tempore ſæpenumero uidetur ex terra eminere media, media adhuc in ea latere. Condũtur uirides ranæ, quæ uerſantur in fluuijs atq; piſcinis, & hæ quidem uocales & edules ſunt. Conduntur ſubliuidæ & ſubcinereæ, quæ item in fluuijs, lacubus, paludibus, lacunis uiuunt: hæ partim uocales & edules ſunt, partim mutæ & non eduntur: quas hybernis menſibus in terra latere argumento eſt, quòd uerno tempore non tantum earũ fœtus conſpiciantur in lacunis, ſed ipſæ ueteres etiam ranæ. Quare uerum non eſt quod ſcribit Plinius: mirumq; ſemeſtri uita reſoluuntur in limum nullo cernente, & rurſus uernis aquis renaſcuntur, quæ fuere natæ: perinde occulta ratione, cum omnibus annis id eueniat: fœtus aũt earum ſunt primo carnes paruæ, rotundæ, nigræ, dein oculis tantum & cauda inſignes: quas Nicander, quia caudam mouent, *μολουρίδας*, Aratus quia rotundæ, *γυρίνους*, alij Græci *βατραχίδας*, quaſi dicas, ranunculos, nominant: quorum poſtea figurantur pedes, priores ex pectore, in poſteriores finditur cauda. Conduntur præterea ranæ pallidæ in hortis agentes, quæ nõ comedũtur, & mutæ ſunt. Cõditur deniq; rana rubeta, quæ ex rubis, ſub uepribus enim uerſari ſolet, nomen inuenit: eam Poeta bufonem, Græci *φρύνον* uocãt. Duo eius genera, altera terrena, quæ in domibus & uepribus agit: altera paluſtris, quæ ſui generis uocem edit. Vtraq; uenenata eſt, utraq;, ſi bacillo ſæpius uerberetur, inflato corpore uirus primò è clunibus exprimit longius, deinde ſudat: cuius ſudoris lactei guttæ admodum grauis & putidi ſunt odoris: ac cùm occiditur



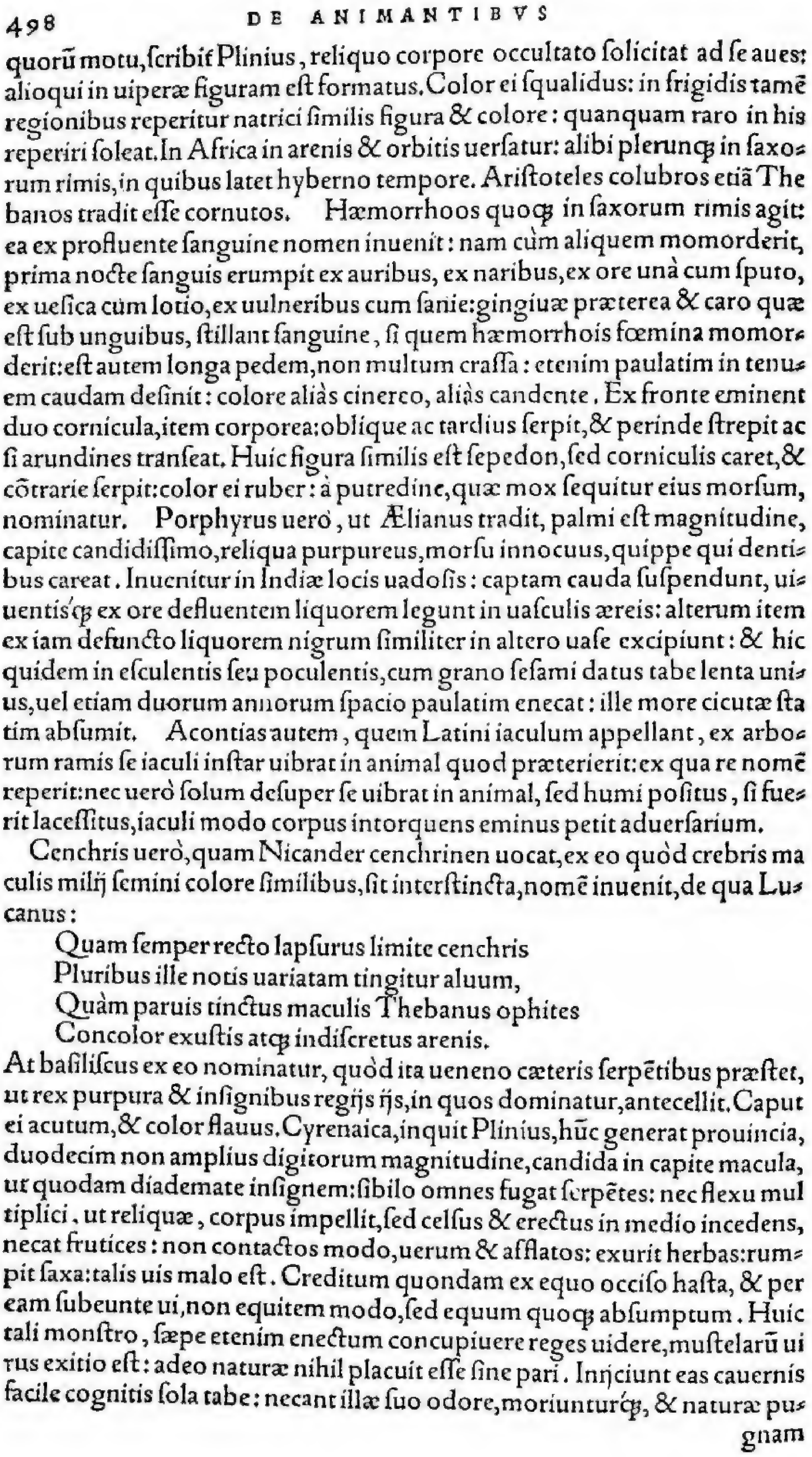
ditur ferè opĳ:occiditur autem difficulter. Rana rubeta mulieres ueneficæ quondã ad ueneficia ſunt uſæ. Mus quoq; aquatilis hyeme latet in ripis fluminũ & riuorum quos incolit. Ei magnitudo ferè muris ſylueſtris: mordet ſæpe manus piſcatorũ, cùm ex foraminib. riparũ, cancros fluuiatiles extrahunt. Vorat piſciculos paruos, quales ſunt gobiones fluuiatiles, & alburni: uorat fœtus lucĳ, ſalaris, barbi, aliorumq́;: quocirca ubi magna uis id genus muriũ naſcitur, riuis uaſtitatem ſolet inferre. Cancer etiã fluuiatilis ſuccedit ripas, & in eis hyeme latet, æſtate plerũq; uerſatur. At ſcorpius, quem Germania tantũmodo importatũ nouit, in terra non latet: quanq̃; in parietibus, & ſub lapidibus. Iam deniq; in ſerpentium genere, qui maxima ex parte terreni ſunt, uipera, quam Græci ἐχίδνην uocant, hyeme ſubit ſaxa. Ea longa eſt circiter cubitum, & maculis in cinereo fuſcis plena. Primò intra ſe oua parit: dein his excluſis uiuas animantes: nec tamen ipſa catulos ſingulos, ut Nicander & Plinius ſcribunt, diebus ſingulis parit uiginti numero: nec cæteræ tarditatis impatientes perrũpunt latera occiſa parente: ſed ut nobis ſerpentiũ ſpeculatores affirmant, uno eodemq́; die catulos plerunq; undecim, plures interdũ parit: & quidem eis ſuperſtes uiuit. Nec uerò etiã cum uiperæ cõmiſcent corpora ſibi circũuolutæ fœmina maris caput inſertũ in os, ut idem Plinius ſcribit, abrodit uoluptatis dulcedine: non aũt mas modo, uerum etiam fœmina natura breuẽ & quaſi mutilam habet caudam, nõ ut pleræq; aliæ ſerpentes longam: ſed differũt inter ſe: etenim fœminæ caput eſt latum, maris acutũ. Cùm hic mordet ac uirus euomit, apparẽt ueſtigia duorũ dentium acutorum: cum illa, plurium: uipera non lac modo ſicuti ſerpentes cæteri, appetit, ſed etiam uinũ: unde eam Galenus in lagenam uino refertam irrepſiſſe ſcribit, & uinũ, in quo demortua fuit, potum elephantiaſe laboranti remedium fuiſſe: contra ad uiperæ morſum multa faciunt, ſed maxime taxi arboris ſuccum facere Claudium Cæſarem edicto propoſito Romanos admonuiſſe Suetonius ſcriptum reliquit. Minori aũt uiperæ dipſas eſt aſſimilis: quæ cùm alba ſit, eius caudam duæ nigræ diſtinguunt lineæ: à ſe ictum inexplebili ſiti enecat, ex quo nomen hoc duxit: quin ipſa multum ſitit: quocirca immoderato potu onuſtæ umbilicus rumpitur, et grauius onus effundit: hanc alĳ cauſonem, alĳ preſterem uocant: ſed preſter, ut corporis forma non multum à dipſade differat, effectu differt: nam ictũ extemplo ſideratione quadam reddit immobilem ac mente alienum: mox pilis defluentibus cum pruritu ac uentris ſolutione abſumit. Condit etiam ſe in terra, ſicuti cæteræ ſerpentes ferè omnes, uel in ſaxorum rimis cæcula: ex cæcitate apud Germanos quoq; nominata: quã eadẽ de cauſa Nicander τυφλῶπα, alĳ τυφλῖνον nominant: etem̃ caret oculis. Color ei in luteo uiridis, & ualde ſplendens: nunq̃; pede eſt longior, nunquam digito craſſior, ea ſicut & uipera, ut Columella ſcriptum reliquit, ſæpe cùm in paſcua bos improuide ſupercubuit, laceſſita onere morſum imprimit. Quin amphisbæna hebetes habet oculos: item parua eſt & tarda, ſed biceps: quare alterutro capite, cum ei libitum fuerit, progredi uel regredi poteſt: unde ei nomen impoſitũ: denſæ cuti color inſidet terræ, uarĳs notis diſtinctæ. Huic non diſſimilis eſt figura ſcytale, ſed pinguior: ei craſſitudo quæ manubrio ligonis, longitudo quæ



do quæ lumbrico : hæc cum uerno tempore exuuias poſuerit, fœniculo, ut cæteræ ſerpentes non ueſcitur: ex baculo nomen inuenit. Tum hybernis menſibus in caua terræ uel loca ſaxoſa ingreditur natrix à natando appellata: qua de cauſa à Græcis ex aqua ὕδρος nominatur: & χέρσυδρος, quòd & in terra & in aqua uerſetur. Nec aſſentior Lucano qui cherſydrum à natrice diſtinguit. Eſt aũt infeſta & inimica ranis: forma nõ differt ab aſpide, ſed colore, qui ei plerunq; in cinereo candidus. Ex natricũ genere uidetur eſſe Calabricus ſerpens, etiamſi maculoſus ſit. Eum his uerſibus deſcribit Virgil.

Eſt etiam ille malus Calabris in ſaltibus anguis,
Squammea conuoluens ſublato pectore terga,
Atq; notis longam maculoſus grandibus aluum,
Qui dum amnes ulli rumpuntur fontibus, & dum
Vere madent udo terræ, ac pluuialibus auſtris
Stagna colit, ripiſq́; habitans hic piſcibus atram
Improbus ingluuiem, raniſq́; loquacibus explet.
Poſtquam exhauſta palus, terræq́; ardore dehiſcunt,
Exilit in ſiccum, & flammantia lumina torquens
Sæuit agris, aſperq́; ſiti atq; exterritus æſtu.

Ex natricum præterea genere ſunt boæ, in tantam, Plinio autore, amplitudinem exeũtes, ut, diuo Claudio principe, occiſæ in Vaticano ſolidus in aluò ſpectatus ſit infans. Alũtur primo bubuli lactis ſucco, unde nomen traxere: ſunt eñ nihil aliud quã domeſticæ atq; uernaculæ natrices. Aſpis aũt eſt longitudine IIII. pedũ, craſſitudine haſtæ. Color eis nõ unus: nam alijs ſqualidus, alijs uiridis & uarius, alijs cinereus, alijs igneus : maxime Æthiopicis. Oculi hebetes in temporibus, & iuxta ſupercilia carunculæ inſtar calli eminent: quocirca quaſi ſomniculoſa nictare non ceſſat, ſed animantium ſtrepitu facile excitatur. Gignit eã Ægyptus, Æthiopia, & cæteræ regiones Africæ. Coniugæ, utor Plinij uerbis, fermè uagantur, nec niſi cum compare uita eſt: itaq; alterutra interempta, incredibilis alteri ultionis cura: perſequitur interfectorem, unumq́; eum in quantolibet populi agmine noticia quadam infeſtat: perrumpit omnes difficultates, permeat ſpacia, nec niſi amnibus arcetur, aut præceleri fuga. Huic ichneumon, qui ſimilis eſt muſtelæ, maxime inimicus eſt: itaq; non tantum eius oua perdit, ſed ipſum etiam interficit: etenim mergit ſe limo ſæpius, ſiccatq́; ſole: mox ubi pluribus eodem modo ſe corijs loricauit, in dimicationẽ pergit: in ea caudã attollens ictus irritos auerſus excipit, donec obliquo capite ſpeculatus inuadat in fauces : aſpides autẽ Galenus in tria diſtribuit genera, in chelidonias, cherſeas, ptyadas, à ſputo cognominatas: quas Cleopatra ſibi admouit. Aſpis uerò frigoris impatiens hyeme incluſus atq; abditus latet in arenis : ut in cauis fagis aut quercubus dryinos: ex qua re nomen inuenit: eam alij, ut Nicander ſcribit, hydron, alij chelydron nominant: eſt enim natrici, quod ad caput attinet, ſimilis, ſed tergũ habet cinerei coloris, craſſitudo & longitudo ei eſt mediocris anguillæ, grauiter olet: ranarum fœtus, cauda inſignes perſequitur: & eam contra muſca magna. At ceraſtes ex cornibus nomen traxit, quæ modo cochleæ inſtar gemina, modo quadrigemina geſtat in capite : & quidem corporea:



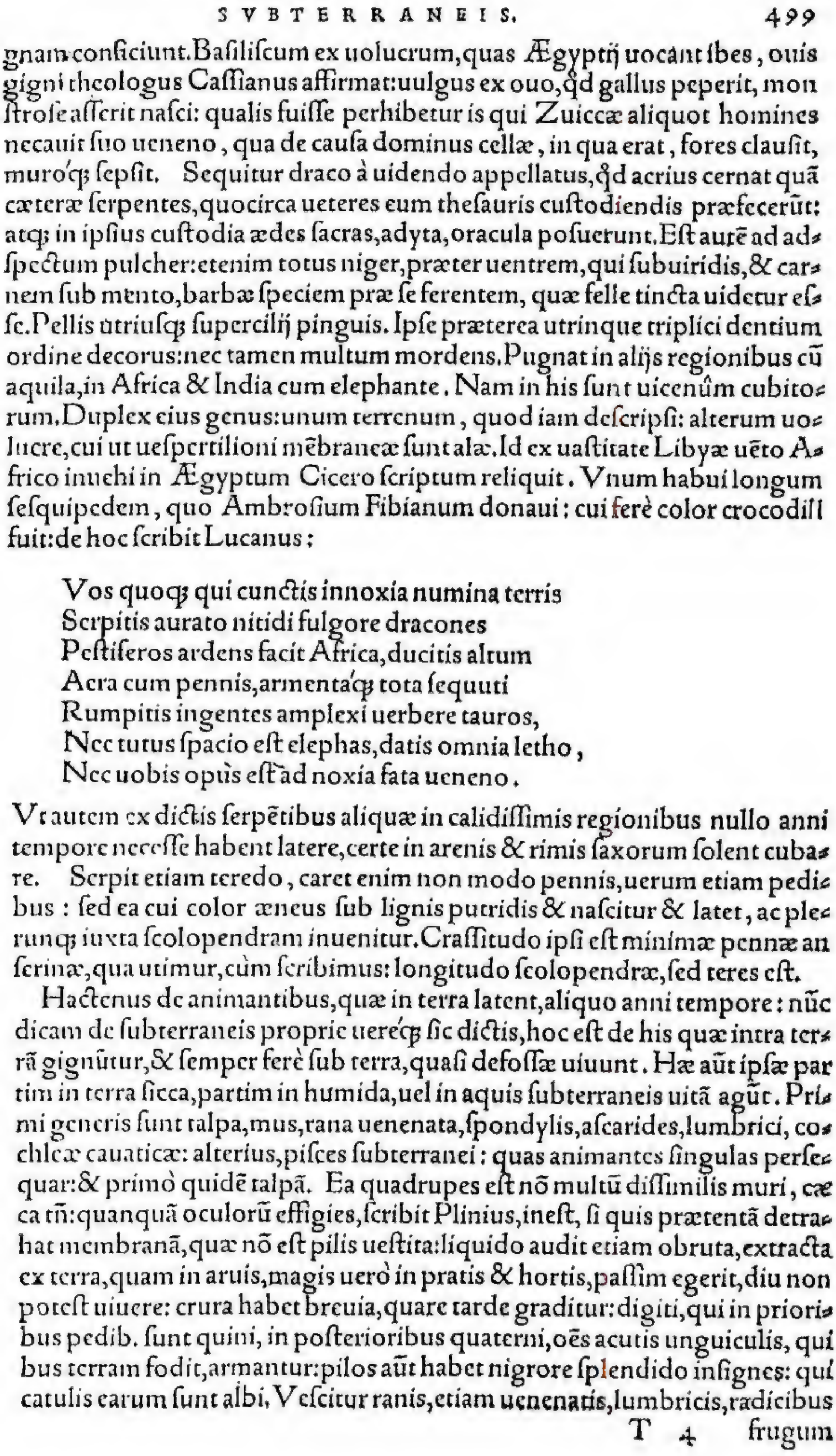
498 DE ANIMANTIBVS

quorũ motu, ſcribit Plinius, reliquo corpore occultato ſolicitat ad ſe aues: alioqui in uiperæ figuram eſt formatus. Color ei ſqualidus: in frigidis tamẽ regionibus reperitur natrici ſimilis figura & colore : quanquam raro in his reperiri ſoleat. In Africa in arenis & orbitis uerſatur: alibi plerunq; in ſaxorum rimis, in quibus latet hyberno tempore. Ariſtoteles colubros etiã Thebanos tradit eſſe cornutos. Hæmorrhoos quoq; in ſaxorum rimis agit: ea ex profluente ſanguine nomen inuenit : nam cùm aliquem momorderit, prima nocte ſanguis erumpit ex auribus, ex naribus, ex ore unà cum ſputo, ex ueſica cùm lotio, ex uulneribus cum ſanie: gingiuæ præterea & caro quæ eſt ſub unguibus, ſtillant ſanguine, ſi quem hæmorrhois fœmina momorderit: eſt autem longa pedem, non multum craſſa : etenim paulatim in tenuem caudam deſinit : colore aliàs cinereo, aliàs candente. Ex fronte eminent duo cornicula, item corporea: oblique ac tardius ſerpit, & perinde ſtrepit ac ſi arundines tranſeat. Huic figura ſimilis eſt ſepedon, ſed corniculis caret, & cõtrarie ſerpit: color ei ruber : à putredine, quæ mox ſequitur eius morſum, nominatur. Porphyrus uerò, ut Ælianus tradit, palmi eſt magnitudine, capite candidiſſimo, reliqua purpureus, morſu innocuus, quippe qui dentibus careat. Inuenitur in Indiæ locis uadoſis : captam cauda ſuſpendunt, uiuentiſq; ex ore defluentem liquorem legunt in uaſculis æreis: alterum item ex iam defuncto liquorem nigrum ſimiliter in altero uaſe excipiunt : & hic quidem in eſculentis ſeu poculentis, cum grano ſeſami datus tabe lenta unius, uel etiam duorum annorum ſpacio paulatim enecat : ille more cicutæ ſtatim abſumit. Acontias autem, quem Latini iaculum appellant, ex arborum ramis ſe iaculi inſtar uibrat in animal quod præterierit: ex qua re nomẽ reperit: nec uerò ſolum deſuper ſe uibrat in animal, ſed humi poſitus, ſi fuerit laceſſitus, iaculi modo corpus intorquens eminus petit aduerſarium.

Cenchris uerò, quam Nicander cenchrinen uocat, ex eo quòd crebris maculis miliĳ ſemini colore ſimilibus, ſit interſtincta, nomẽ inuenit, de qua Lucanus :

Quam ſemper recto lapſurus limite cenchris
Pluribus ille notis uariatam tingitur aluum,
Quàm paruis tinctus maculis Thebanus ophites
Concolor exuſtis atq; indiſcretus arenis.

At baſiliſcus ex eo nominatur, quòd ita ueneno cæteris ſerpẽtibus præſtet, ut rex purpura & inſignibus regĳs ĳs, in quos dominatur, antecellit. Caput ei acutum, & color flauus. Cyrenaica, inquit Plinius, hũc generat prouincia, duodecim non amplius digitorum magnitudine, candida in capite macula, ut quodam diademate inſignem: ſibilo omnes fugat ſerpẽtes: nec flexu multiplici, ut reliquæ, corpus impellit, ſed celſus & erectus in medio incedens, necat frutices : non contactos modo, uerum & afflatos: exurit herbas: rumpit ſaxa: talis uis malo eſt. Creditum quondam ex equo occiſo haſta, & per eam ſubeunte ui, non equitem modo, ſed equum quoq; abſumptum. Huic tali monſtro, ſæpe etenim enectum concupiuere reges uidere, muſtelarũ uirus exitio eſt : adeo naturæ nihil placuit eſſe ſine pari. Inĳciunt eas cauernis facile cognitis ſola tabe: necant illæ ſuo odore, moriunturq;, & naturæ pugnam



SVBTERRANEIS. 499

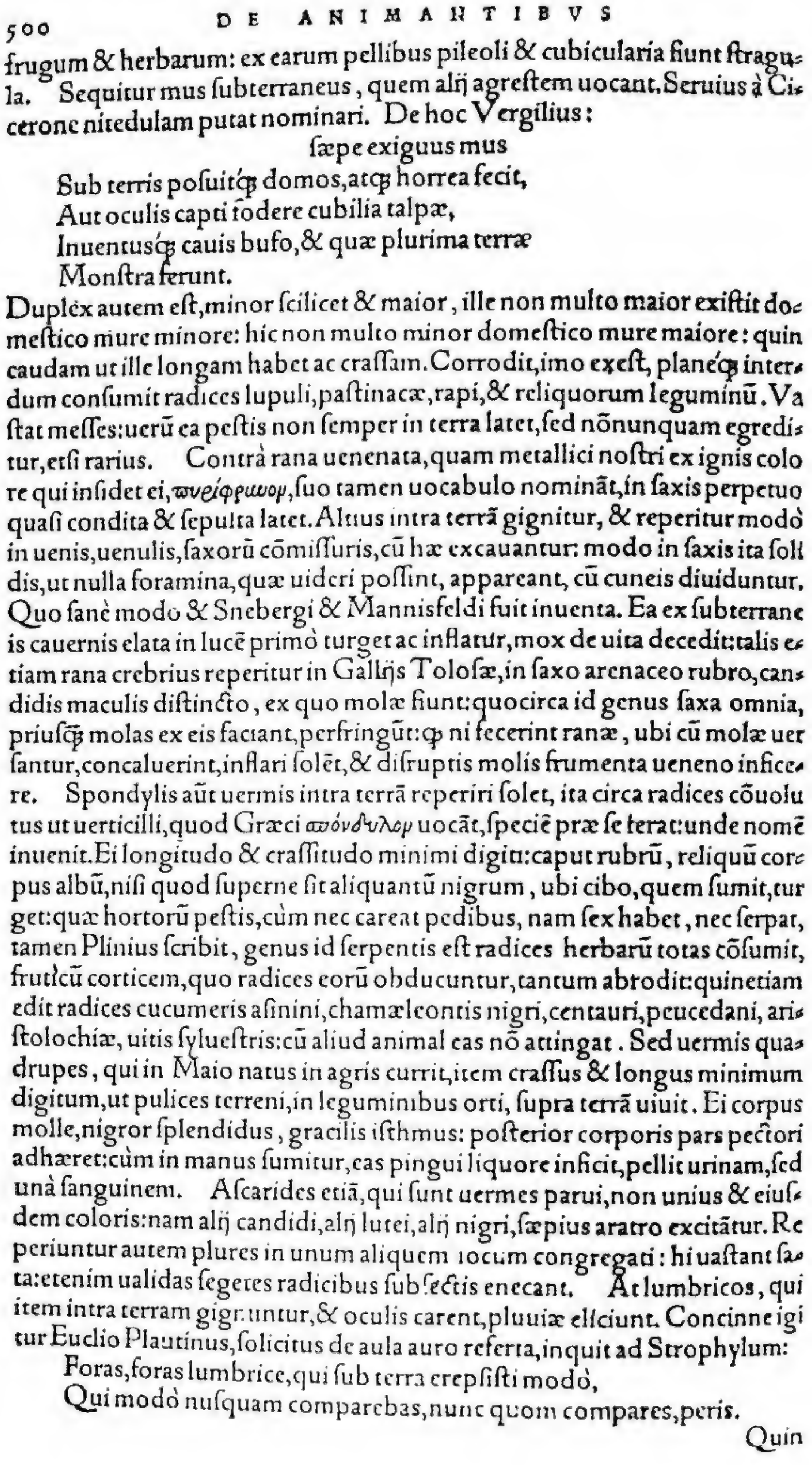
gnam conficiunt. Baſiliſcum ex uolucrum, quas Ægyptij uocant ibes, ouis gigni theologus Caſſianus affirmat: uulgus ex ouo, q̊d gallus peperit, monſtroſe aſſerit naſci: qualis fuiſſe perhibetur is qui Zuiccæ aliquot homines necauit ſuo ueneno, qua de cauſa dominus cellæ, in qua erat, fores clauſit, muróq; ſepſit. Sequitur draco à uidendo appellatus, q̊d acrius cernat quã cæteræ ſerpentes, quocirca ueteres eum theſauris cuſtodiendis præfecerũt: atq; in ipſius cuſtodia ædes ſacras, adyta, oracula poſuerunt. Eſt autẽ ad adſpectum pulcher: etenim totus niger, præter uentrem, qui ſubuiridis, & carnem ſub mento, barbæ ſpeciem præ ſe ferentem, quæ felle tincta uidetur eſſe. Pellis utriuſq; ſupercilij pinguis. Ipſe præterea utrinque triplici dentium ordine decorus: nec tamen multum mordens. Pugnat in alijs regionibus cũ aquila, in Africa & India cum elephante. Nam in his ſunt uicenûm cubitorum. Duplex eius genus: unum terrenum, quod iam deſcripſi: alterum uolucre, cui ut ueſpertilioni mẽbraneæ ſunt alæ. Id ex uaſtitate Libyæ uẽto Africo inuehi in Ægyptum Cicero ſcriptum reliquit. Vnum habui longum ſeſquipedem, quo Ambroſium Fibianum donaui: cui ferè color crocodili fuit: de hoc ſcribit Lucanus:

Vos quoq; qui cunctis innoxia numina terris
Serpitis aurato nitidi fulgore dracones
Peſtiferos ardens facit Africa, ducitis altum
Aera cum pennis, armentáq; tota ſequuti
Rumpitis ingentes amplexi uerbere tauros,
Nec tutus ſpacio eſt elephas, datis omnia letho,
Nec uobis opùs eſt ad noxia fata ueneno.

Vt autem ex dictis ſerpẽtibus aliquæ in calidiſſimis regionibus nullo anni tempore neceſſe habent latere, certe in arenis & rimis ſaxorum ſolent cubare. Serpit etiam teredo, caret enim non modo pennis, uerum etiam pedibus: ſed ea cui color æneus ſub lignis putridis & naſcitur & latet, ac plerunq; iuxta ſcolopendram inuenitur. Craſſitudo ipſi eſt minimæ pennæ anſerinæ, qua utimur, cùm ſcribimus: longitudo ſcolopendræ, ſed teres eſt.

Hactenus de animantibus, quæ in terra latent, aliquo anni tempore: nũc dicam de ſubterraneis proprie ueréq; ſic dictis, hoc eſt de his quæ intra terrã gignũtur, & ſemper ferè ſub terra, quaſi defoſſæ uiuunt. Hæ aũt ipſæ partim in terra ſicca, partim in humida, uel in aquis ſubterraneis uitã agũt. Primi generis ſunt talpa, mus, rana uenenata, ſpondylis, aſcarides, lumbrici, cochleæ cauaticæ: alterius, piſces ſubterranei: quas animantes ſingulas perſequar: & primò quidẽ talpã. Ea quadrupes eſt nõ multũ diſſimilis muri, cæca tñ: quanquã oculorũ effigies, ſcribit Plinius, ineſt, ſi quis prætentã detrahat membranã, quæ nõ eſt pilis ueſtita: liquido audit etiam obruta, extracta ex terra, quam in aruis, magis uerò in pratis & hortis, paſſim egerit, diu non poteſt uiuere: crura habet breuia, quare tarde graditur: digiti, qui in prioribus pedib. ſunt quini, in poſterioribus quaterni, oẽs acutis unguiculis, quibus terram fodit, armantur: pilos aũt habet nigrore ſplendido inſignes: qui catulis earum ſunt albi. Veſcitur ranis, etiam uenenatis, lumbricis, radicibus

T 4 frugum



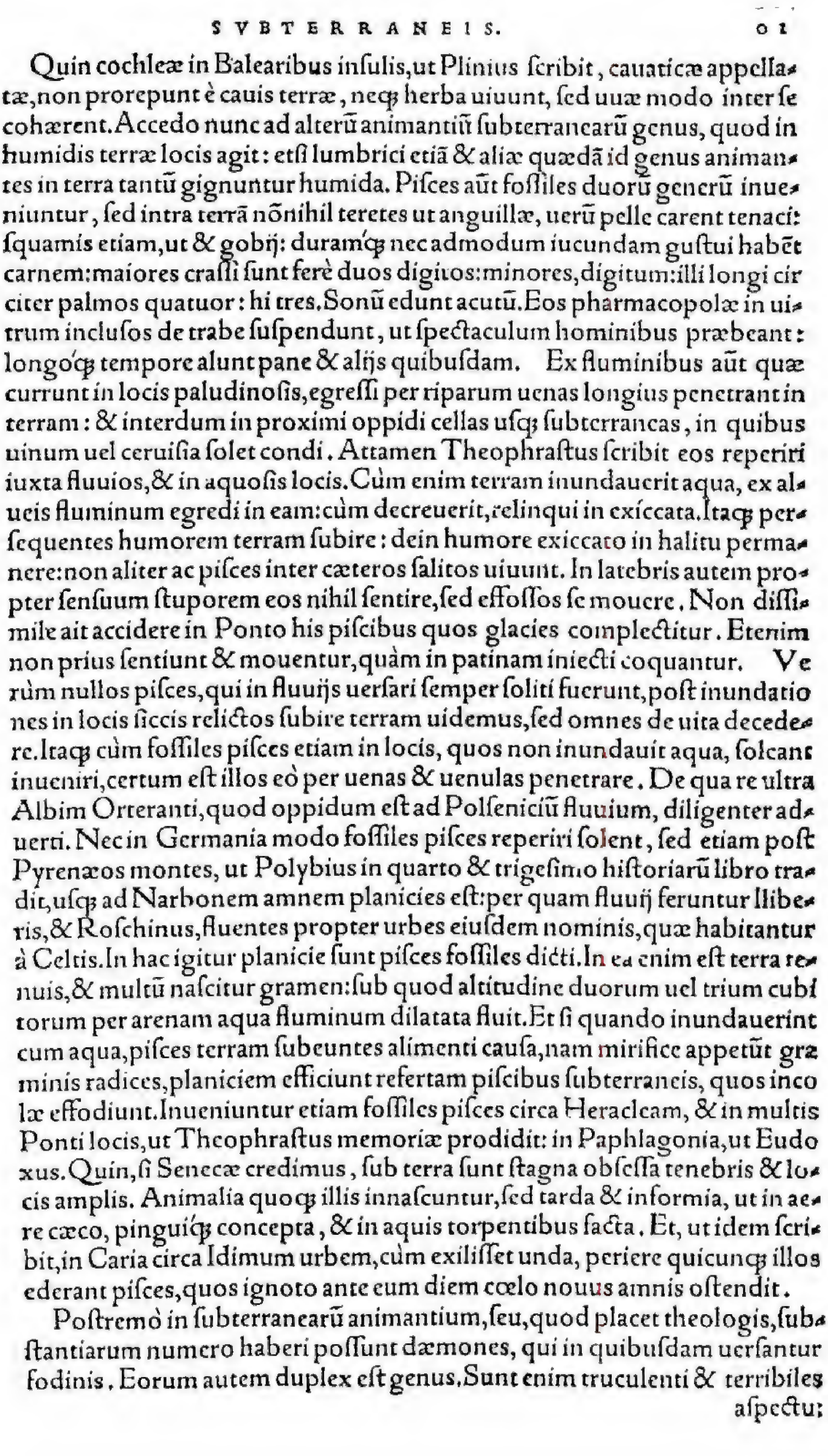
frugum & herbarum: ex earum pellibus pileoli & cubicularia fiunt ſtragula. Sequitur mus ſubterraneus, quem alij agreſtem uocant. Seruius à Cicerone nitedulam putat nominari. De hoc Vergilius:

ſæpe exiguus mus
Sub terris poſuitq́ domos, atq́ horrea fecit,
Aut oculis capti fodere cubilia talpæ,
Inuentusq́ cauis bufo, & quæ plurima terræ
Monſtra ferunt.

Duplex autem eſt, minor ſcilicet & maior, ille non multo maior exiſtit domeſtico mure minore: hic non multo minor domeſtico mure maiore: quin caudam ut ille longam habet ac craſſam. Corrodit, imo exeſt, planeq́ interdum conſumit radices lupuli, paſtinacæ, rapi, & reliquorum legumínũ. Vaſtat meſſes: uerũ ea peſtis non ſemper in terra latet, ſed nõnunquam egreditur, etſi rarius. Contrà rana uenenata, quam metallici noſtri ex ignis colore qui inſidet ei, πυρίφρυνον, ſuo tamen uocabulo nominãt, in ſaxis perpetuo quaſi condita & ſepulta latet. Altius intra terrã gignitur, & reperitur modò in uenis, uenulis, ſaxorũ cõmiſſuris, cũ hæ excauantur: modo in ſaxis ita ſolidis, ut nulla foramina, quæ uideri poſſint, appareant, cũ cuneis diuiduntur. Quo ſanè modo & Snebergi & Mannisfeldi fuit inuenta. Ea ex ſubterraneis cauernis elata in lucẽ primò turget ac inflatur, mox de uita decedit: talis etiam rana crebrius reperitur in Gallijs Toloſæ, in ſaxo arenaceo rubro, candidis maculis diſtincto, ex quo molæ fiunt: quocirca id genus ſaxa omnia, priuſq́ molas ex eis faciant, perfringũt: ꝙ ni fecerint ranæ, ubi cũ molæ uerſantur, concaluerint, inflari ſolẽt, & diſruptis molis frumenta ueneno inficere. Spondylis aũt uermis intra terrã reperiri ſolet, ita circa radices cõuolutus ut uerticilli, quod Græci σπόνδυλον uocãt, ſpeciẽ præ ſe ferat: unde nomẽ inuenit. Ei longitudo & craſſitudo minimi digiti: caput rubrũ, reliquũ corpus albũ, niſi quod ſuperne ſit aliquantũ nigrum, ubi cibo, quem ſumit, turget: quæ hortorũ peſtis, cùm nec careat pedibus, nam ſex habet, nec ſerpat, tamen Plinius ſcribit, genus id ſerpentis eſt radices herbarũ totas cõſumit, fruticũ corticem, quo radices eorũ obducuntur, tantum abrodit: quinetiam edit radices cucumeris aſinini, chamæleontis nigri, centauri, peucedani, ariſtolochiæ, uitis ſylueſtris: cũ aliud animal eas nõ attingat. Sed uermis quadrupes, qui in Maio natus in agris currit, item craſſus & longus minimum digitum, ut pulices terreni, in leguminibus orti, ſupra terrã uiuit. Ei corpus molle, nigror ſplendidus, gracilis iſthmus: poſterior corporis pars pectori adhæret: cùm in manus ſumitur, eas pingui liquore inficit, pellit urinam, ſed unà ſanguinem. Aſcarides etiã, qui ſunt uermes parui, non unius & eiuſdem coloris: nam alij candidi, alij lutei, alij nigri, ſæpius aratro excitãtur. Reperiuntur autem plures in unum aliquem locum congregati: hi uaſtant ſata: etenim ualidas ſegetes radicibus ſubſectis enecant. At lumbricos, qui item intra terram gignuntur, & oculis carent, pluuiæ eliciunt. Concinne igitur Euclio Plautinus, ſolicitus de aula auro referta, inquit ad Strophylum:

Foras, foras lumbrice, qui ſub terra erepſiſti modò,
Qui modò nuſquam comparebas, nunc quom compares, peris.

Quin

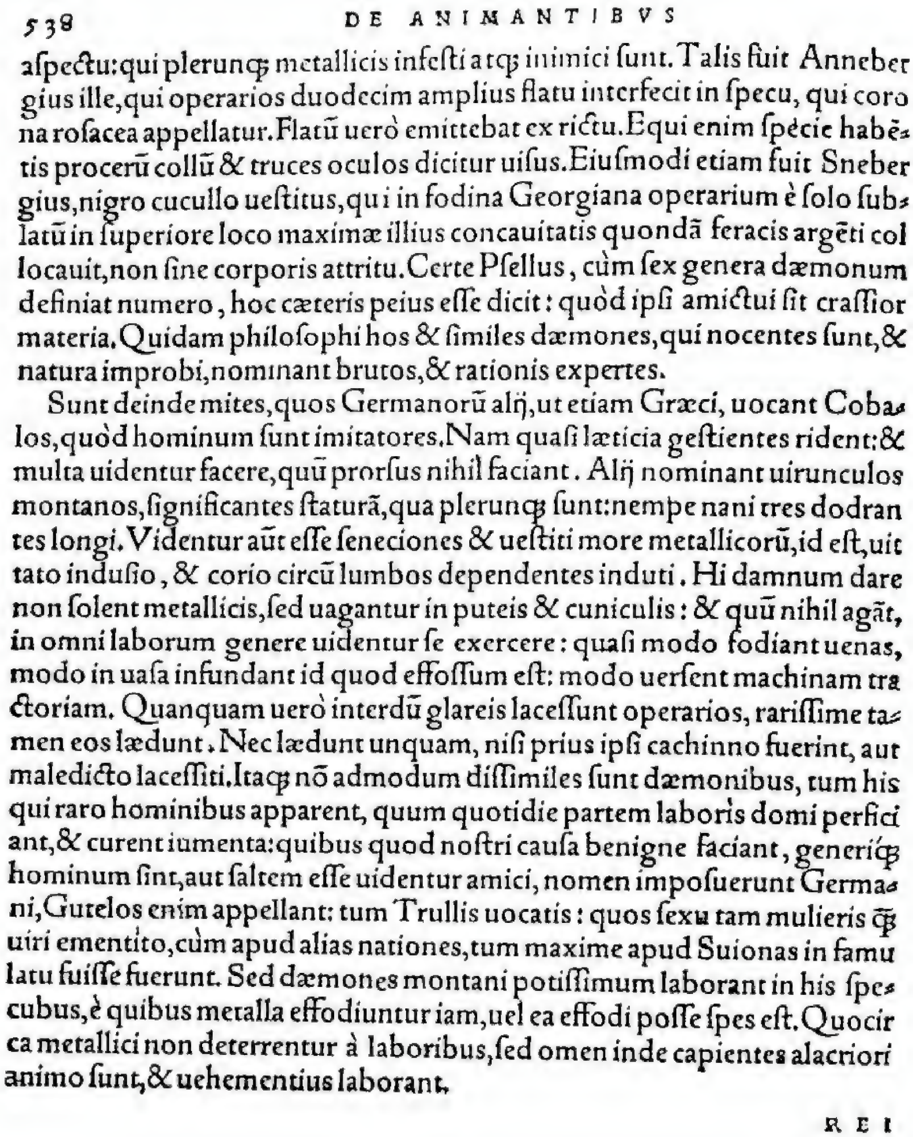


[501]

Quin cochleæ in Balearibus inſulis,ut Plinius ſcribit, cauaticæ appellatæ,non prorepunt è cauis terræ, neq; herba uiuunt, ſed uuæ modo inter ſe cohærent. Accedo nunc ad alterũ animantiũ ſubterranearũ genus, quod in humidis terræ locis agit: etſi lumbrici etiã & aliæ quædã id genus animantes in terra tantũ gignuntur humida. Piſces aũt foſſiles duorũ generũ inueniuntur, ſed intra terrã nõnihil teretes ut anguillæ, uerũ pelle carent tenaci: ſquamis etiam,ut & gobij: duramq́; nec admodum iucundam guſtui habẽt carnem: maiores craſſi ſunt ferè duos digitos: minores, digitum: illi longi circiter palmos quatuor: hi tres. Sonũ edunt acutũ. Eos pharmacopolæ in uitrum incluſos de trabe ſuſpendunt, ut ſpectaculum hominibus præbeant: longoq́; tempore alunt pane & alijs quibuſdam. Ex fluminibus aũt quæ currunt in locis paludinoſis, egreſſi per riparum uenas longius penetrant in terram: & interdum in proximi oppidi cellas uſq; ſubterraneas, in quibus uinum uel ceruiſia ſolet condi. Attamen Theophraſtus ſcribit eos reperiri iuxta fluuios, & in aquoſis locis. Cùm enim terram inundauerit aqua, ex alueis fluminum egredi in eam: cùm decreuerit, relinqui in exiccata. Itaq; perſequentes humorem terram ſubire: dein humore exiccato in halitu permanere: non aliter ac piſces inter cæteros ſalitos uiuunt. In latebris autem propter ſenſuum ſtuporem eos nihil ſentire, ſed effoſſos ſe mouere. Non diſſimile ait accidere in Ponto his piſcibus quos glacies complectitur. Etenim non prius ſentiunt & mouentur, quàm in patinam iniecti coquantur. Verùm nullos piſces, qui in fluuijs uerſari ſemper ſoliti fuerunt, poſt inundationes in locis ſiccis relictos ſubire terram uidemus, ſed omnes de uita decedere. Itaq; cùm foſſiles piſces etiam in locis, quos non inundauit aqua, ſoleant inueniri, certum eſt illos eò per uenas & uenulas penetrare. De qua re ultra Albim Orteranti, quod oppidum eſt ad Polſeniciũ fluuium, diligenter aduerti. Nec in Germania modo foſſiles piſces reperiri ſolent, ſed etiam poſt Pyrenæos montes, ut Polybius in quarto & trigeſimo hiſtoriarũ libro tradit, uſq; ad Narbonem amnem planicies eſt: per quam fluuij feruntur Illiberis, & Roſchinus, fluentes propter urbes eiuſdem nominis, quæ habitantur à Celtis. In hac igitur planicie ſunt piſces foſſiles dicti. In ea enim eſt terra tenuis, & multũ naſcitur gramen: ſub quod altitudine duorum uel trium cubitorum per arenam aqua fluminum dilatata fluit. Et ſi quando inundauerint cum aqua, piſces terram ſubeuntes alimenti cauſa, nam mirifice appetũt graminis radices, planiciem efficiunt refertam piſcibus ſubterraneis, quos incolæ effodiunt. Inueniuntur etiam foſſiles piſces circa Heracleam, & in multis Ponti locis, ut Theophraſtus memoriæ prodidit: in Paphlagonia, ut Eudoxus. Quin, ſi Senecæ credimus, ſub terra ſunt ſtagna obſeſſa tenebris & locis amplis. Animalia quoq; illis innaſcuntur, ſed tarda & informia, ut in aere cæco, pinguiq́; concepta, & in aquis torpentibus facta. Et, ut idem ſcribit, in Caria circa Idimum urbem, cùm exiliſſet unda, periere quicunq; illos ederant piſces, quos ignoto ante eum diem cœlo nouus amnis oſtendit.

Poſtremò in ſubterranearũ animantium, ſeu, quod placet theologis, ſubſtantiarum numero haberi poſſunt dæmones, qui in quibuſdam uerſantur fodinis. Eorum autem duplex eſt genus. Sunt enim truculenti & terribiles

aſpectu;

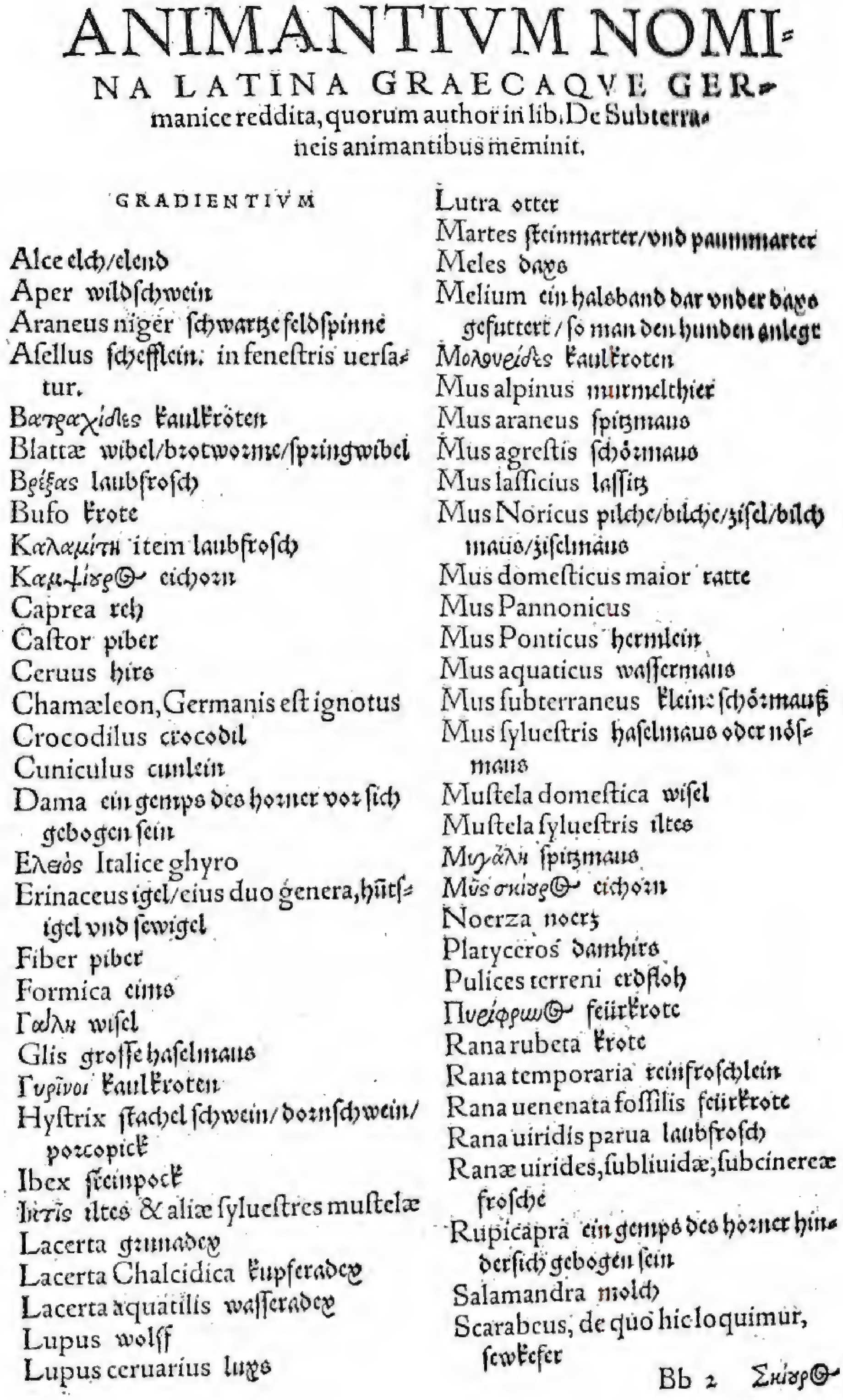


538 DE ANIMANTIBVS

aſpectu: qui plerunq; metallicis infeſti atq; inimici ſunt. Talis fuit Annebergius ille, qui operarios duodecim amplius flatu interfecit in ſpecu, qui corona roſacea appellatur. Flatū uerò emittebat ex rictu. Equi enim ſpécie habētis procerū collū & truces oculos dicitur uiſus. Eiuſmodi etiam fuit Snebergius, nigro cucullo ueſtitus, qui in fodina Georgiana operarium è ſolo ſublatū in ſuperiore loco maximæ illius concauitatis quondā feracis argēti collocauit, non ſine corporis attritu. Certe Pſellus, cùm ſex genera dæmonum definiat numero, hoc cæteris peius eſſe dicit: quòd ipſi amictui ſit craſſior materia. Quidam philoſophi hos & ſimiles dæmones, qui nocentes ſunt, & natura improbi, nominant brutos, & rationis expertes.

Sunt deinde mites, quos Germanorū alij, ut etiam Græci, uocant Cobalos, quòd hominum ſunt imitatores. Nam quaſi lætícia geſtientes rident: & multa uidentur facere, quū prorſus nihil faciant. Alij nominant uirunculos montanos, ſignificantes ſtaturā, qua plerunq; ſunt: nempe nani tres dodrantes longi. Videntur aūt eſſe ſeneciones & ueſtiti more metallicorū, id eſt, uittato induſio, & corio circū lumbos dependentes induti. Hi damnum dare non ſolent metallicis, ſed uagantur in puteis & cuniculis: & quū nihil agāt, in omni laborum genere uidentur ſe exercere: quaſi modo fodiant uenas, modo in uaſa infundant id quod effoſſum eſt: modo uerſent machinam tractoriam. Quanquam uerò interdū glareis laceſſunt operarios, rariſſime tamen eos lædunt. Nec lædunt unquam, niſi prius ipſi cachinno fuerint, aut maledicto laceſſiti. Itaq; nō admodum diſſimiles ſunt dæmonibus, tum his qui raro hominibus apparent, quum quotidie partem laboris domi perficiant, & curent iumenta: quibus quod noſtri cauſa benigne faciant, generiq; hominum ſint, aut ſaltem eſſe uidentur amici, nomen impoſuerunt Germani, Gutelos enim appellant: tum Trullis uocatis: quos ſexu tam mulieris ꝗ uiri ementito, cùm apud alias nationes, tum maxime apud Suionas in famulatu fuiſſe fuerunt. Sed dæmones montani potiſſimum laborant in his ſpecubus, è quibus metalla effodiuntur iam, uel ea effodi poſſe ſpes eſt. Quocirca metallici non deterrentur à laboribus, ſed omen inde capientes alacriori animo ſunt, & uehementius laborant.

REI

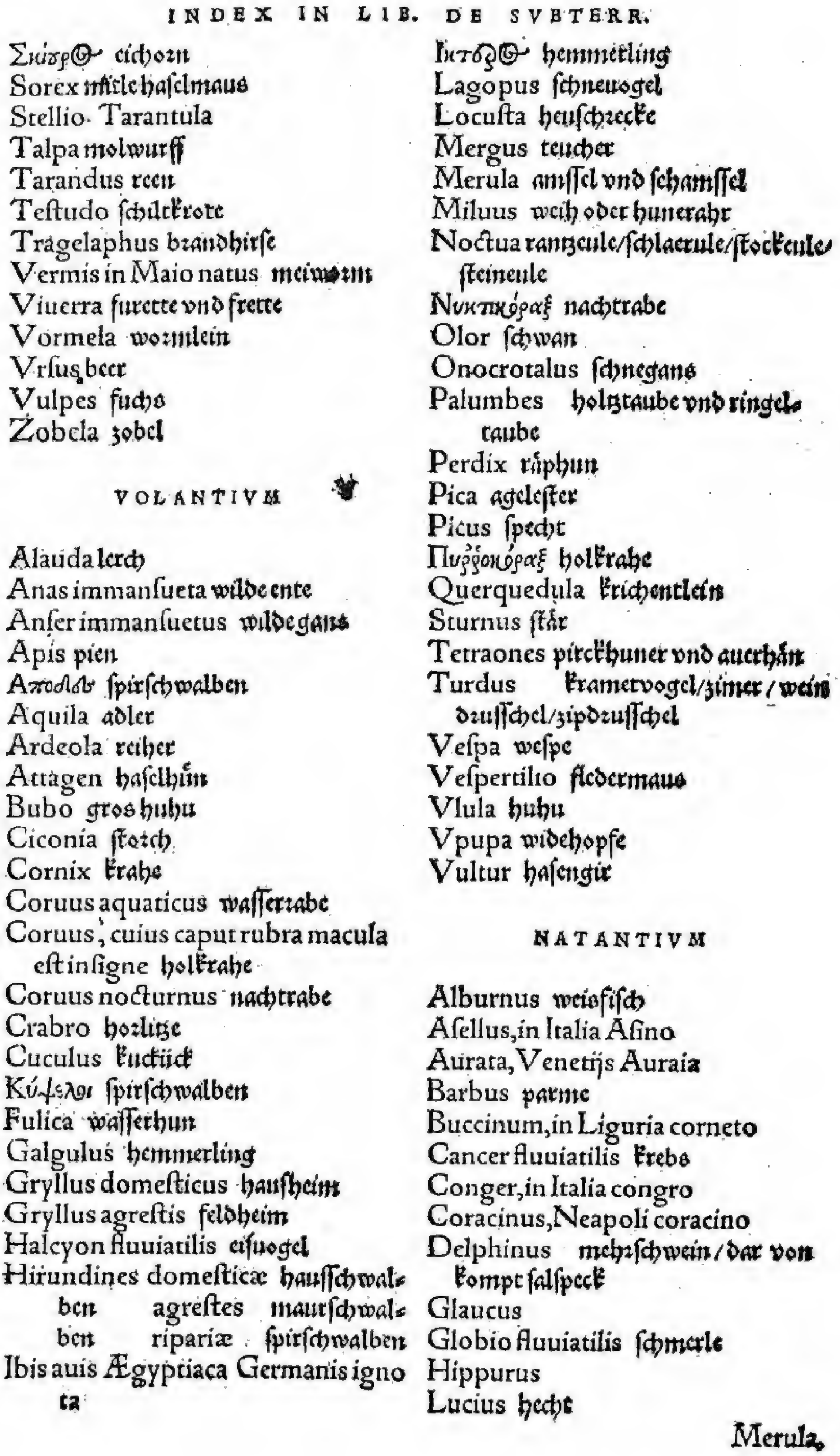


ANIMANTIVM NOMINA LATINA GRAECAQVE GERmanice reddita, quorum author in lib. De Subterraneis animantibus meminit.

GRADIENTIVM

Alce elch/elend
Aper wildſchwein
Araneus niger ſchwartze feldſpinne
Aſellus ſcheſſlein: in feneſtris uerſatur.
Βατραχίδες kaulkröten
Blattæ wibel/brotworme/ſpringwibel
Βρέξας laubfroſch
Bufo krote
Καλαμίτη item laubfroſch
Καμψίουρος eichorn
Caprea reh
Caſtor piber
Ceruus hirs
Chamæleon, Germanis eſt ignotus
Crocodilus crocodil
Cuniculus cunlein
Dama ein gemps des horner vor ſich gebogen ſein
Ελειὸς Italice ghyro
Erinaceus igel/eius duo genera, hütſigel vnd ſewigel
Fiber piber
Formica eims
Γαλῆ wiſel
Glis groſſe haſelmaus
Γυρῖνοι kaulkroten
Hyſtrix ſtachel ſchwein/dornſchwein/ porcopick
Ibex ſteinpock
Ικτις iltes & aliæ ſylueſtres muſtelæ
Lacerta grunadex
Lacerta Chalcidica kupferadex
Lacerta aquatilis waſſeradex
Lupus wolff
Lupus ceruarius luxs
Lutra otter
Martes ſteinmarter/vnd paummarter
Meles daxs
Melium ein halsband dar vnder daxs geſuttert / ſo man den hunden anlegt
Μολουρίδες kaulkroten
Mus alpinus murmelthier
Mus araneus ſpitzmaus
Mus agreſtis ſchörmaus
Mus laſſicius laſſitz
Mus Noricus pilche/bilche/ziſel/bilchmaus/ziſelmaus
Mus domeſticus maior ratte
Mus Pannonicus
Mus Ponticus hermlein
Mus aquaticus waſſermaus
Mus ſubterraneus klein: ſchörmauß
Mus ſylueſtris haſelmaus oder nöſmaus
Muſtela domeſtica wiſel
Muſtela ſylueſtris iltes
Μυγάλη ſpitzmaus
Μῦς σκίουρος eichorn
Noerza noerz
Platyceros damhirs
Pulices terreni erdfloh
Πυρίφρυνος feürkrote
Rana rubeta krote
Rana temporaria reinfroſchlein
Rana uenenata foſſilis feürkrote
Rana uiridis parua laubfroſch
Ranæ uirides, ſubliuidæ, ſubcinereæ froſche
Rupicapra ein gemps des horner hinderſich gebogen ſein
Salamandra molch
Scarabeus, de quo hic loquimur, ſewkefer

Bb 2 Σκίουρος



INDEX IN LIB. DE SVBTERR.

Σκίουρος	eichorn
Sorex	mützle haſelmaus
Stellio	Tarantula
Talpa	molwurff
Tarandus	reen
Teſtudo	ſchiltkrote
Tragelaphus	brandhirſe
Vermis in Maio natus	meiworm
Viuerra	furette vnd frette
Vormela	wormlein
Vrſus	beer
Vulpes	fuchs
Zobela	zobel

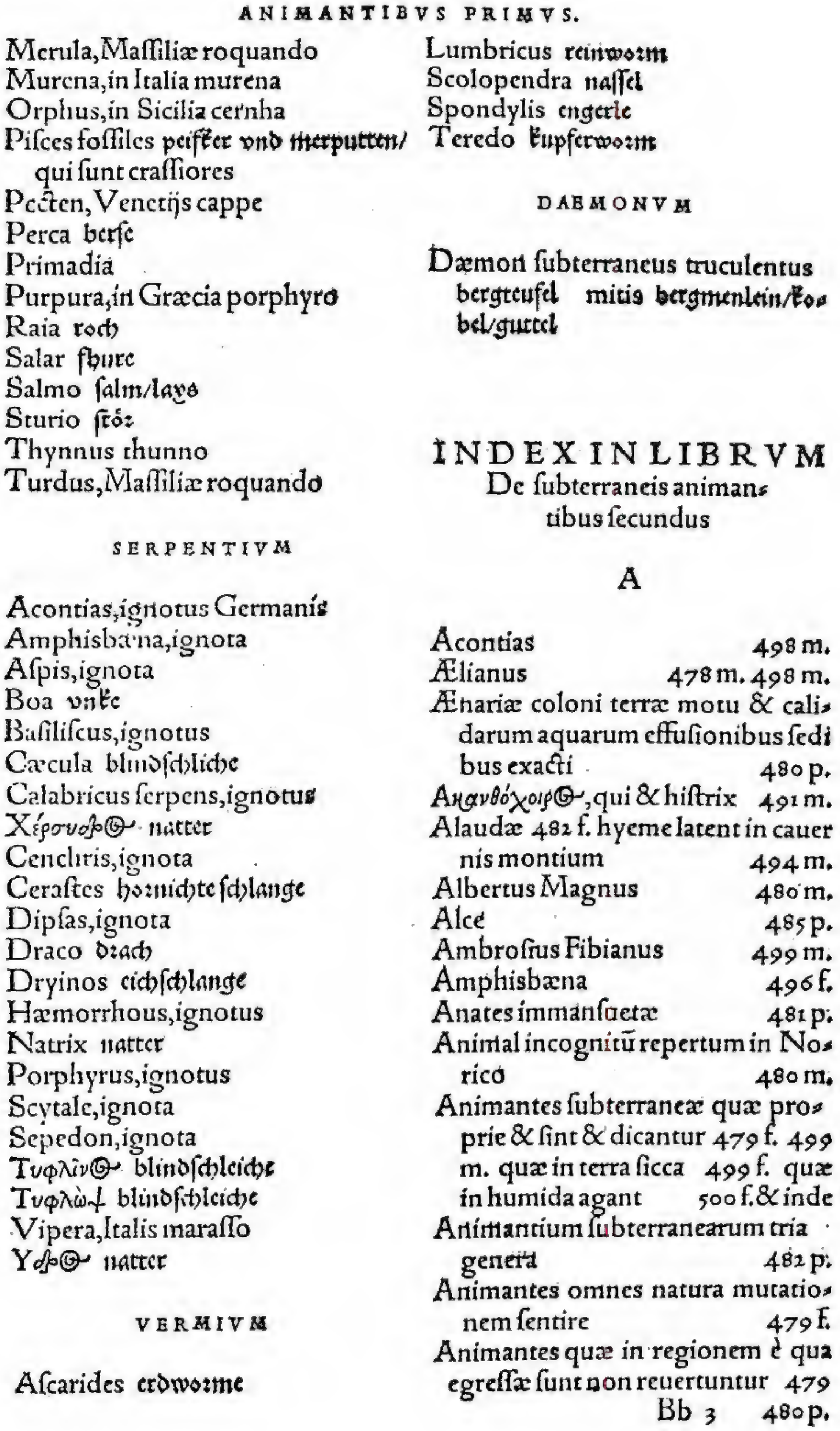
VOLANTIVM

Alauda	lerch
Anas immanſueta	wilde ente
Anſer immanſuetus	wildegans
Apis	pien
Ἄποδες	ſpirſchwalben
Aquila	adler
Ardeola	reiher
Attagen	haſelhün
Bubo	gros huhu
Ciconia	ſtorch
Cornix	krahe
Coruus aquaticus	waſſerrabe
Coruus, cuius caput rubra macula eſt inſigne	holkrahe
Coruus nocturnus	nachtrabe
Crabro	horlitze
Cuculus	kuckück
Κύψελοι	ſpirſchwalben
Fulica	waſſerhun
Galgulus	hemmerling
Gryllus domeſticus	hausheim
Gryllus agreſtis	feldheim
Halcyon fluuiatilis	eiſuogel
Hirundines domeſticæ	hausſchwalben
agreſtes	maurſchwalben
ripariæ	ſpirſchwalben
Ibis auis Ægyptiaca Germanis ignota	
Ἴκτερος	hemmerling
Lagopus	ſchneuogel
Locuſta	heuſchrecke
Mergus	teucher
Merula	amſſel vnd ſchamſſel
Miluus	weih oder hunerahr
Noctua	rantzeule/ſchlaereule/ſtockeule/ſteineule
Νυκτικόραξ	nachtrabe
Olor	ſchwan
Onocrotalus	ſchnegans
Palumbes	holtztaube vnd ringeltaube
Perdix	räphun
Pica	ageleſter
Picus	ſpecht
Πυῤῥοκόραξ	holkrahe
Querquedula	krichentlein
Sturnus	ſtär
Tetraones	pirckhuner vnd auerhän
Turdus	krametvogel/zimer/weindruſſchel/zipdruſſchel
Veſpa	weſpe
Veſpertilio	fledermaus
Vlula	huhu
Vpupa	widehopfe
Vultur	haſengir

NATANTIVM

Alburnus	weisfiſch
Aſellus, in Italia Aſino	
Aurata, Venetijs Auraia	
Barbus	parme
Buccinum, in Liguria corneto	
Cancer fluuiatilis	krebs
Conger, in Italia congro	
Coracinus, Neapoli coracino	
Delphinus	mehrſchwein/dar von kompt ſalſpeck
Glaucus	
Globio fluuiatilis	ſchmerle
Hippurus	
Lucius	hecht

Merula



ANIMANTIBVS PRIMVS.

Merula, Maſſiliæ roquando
Murena, in Italia murena
Orphus, in Sicilia cernha
Piſces foſſiles peiſker vnd merputten/ qui ſunt craſſiores
Pecten, Venetijs cappe
Perca berſe
Primadia
Purpura, in Græcia porphyro
Raia roch
Salar ſchurc
Salmo ſalm/lays
Sturio ſtör
Thynnus thunno
Turdus, Maſſiliæ roquando

SERPENTIVM

Acontias, ignotus Germanis
Amphisbæna, ignota
Aſpis, ignota
Boa vnke
Baſiliſcus, ignotus
Cæcula blindſchliche
Calabricus ſerpens, ignotus
Χέρσυδρος natter
Cenchris, ignota
Ceraſtes hornichte ſchlange
Dipſas, ignota
Draco drach
Dryinos eichſchlange
Hæmorrhous, ignotus
Natrix natter
Porphyrus, ignotus
Scytale, ignota
Sepedon, ignota
Τυφλῖνος blindſchleiche
Τυφλὼψ blindſchleiche
Vipera, Italis maraſſo
Ὕδρος natter

VERMIVM

Aſcarides erdworme
Lumbricus reinworm
Scolopendra naſſel
Spondylis engerle
Teredo kupferworm

DAEMONVM

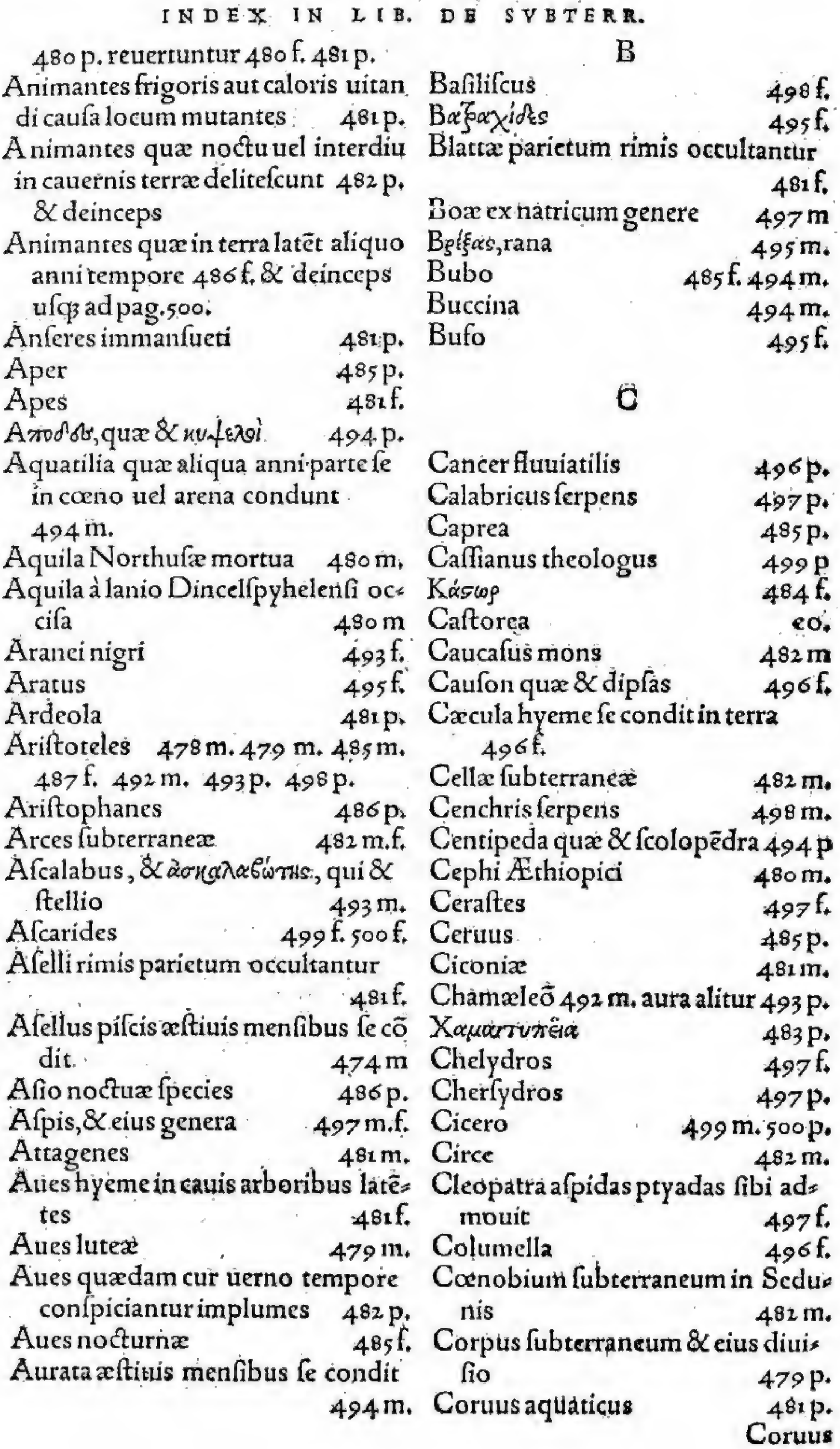
Dæmon ſubterraneus truculentus bergteufel mitis bergmenlein/kobel/guttel

INDEX IN LIBRVM
De ſubterraneis animantibus ſecundus

A

Acontias 498 m.
Ælianus 478 m. 498 m.
Ænariæ coloni terræ motu & calidarum aquarum effuſionibus ſedibus exacti 480 p.
Ἀκανθόχοιρος, qui & hiſtrix 491 m.
Alaudæ 482 f. hyeme latent in cauernis montium 494 m.
Albertus Magnus 480 m.
Alce 485 p.
Ambroſius Fibianus 499 m.
Amphisbæna 496 f.
Anates immanſuetæ 481 p.
Animal incognitũ repertum in Norico 480 m.
Animantes ſubterraneæ quæ proprie & ſint & dicantur 479 f. 499 m. quæ in terra ſicca 499 f. quæ in humida agant 500 f. & inde
Animantium ſubterranearum tria genera 482 p.
Animantes omnes natura mutationem ſentire 479 f.
Animantes quæ in regionem è qua egreſſæ ſunt non reuertuntur 479 480 p.

Bb 3



INDEX IN LIB. DE SVBTERR.

480 p. reuertuntur 480 f. 481 p.
Animantes frigoris aut caloris uitandi cauſa locum mutantes 481 p.
Animantes quæ noctu uel interdiu in cauernis terræ deliteſcunt 482 p. & deinceps
Animantes quæ in terra latẽt aliquo anni tempore 486 f. & deinceps uſq; ad pag. 500.
Anſeres immanſueti 481 p.
Aper 485 p.
Apes 481 f.
Ἀποδες, quæ & κυψελοὶ 494 p.
Aquatilia quæ aliqua anni parte ſe in cœno uel arena condunt 494 m.
Aquila Northuſæ mortua 480 m.
Aquila à lanio Dincelſpyhelenſi occiſa 480 m
Aranei nigri 493 f.
Aratus 495 f.
Ardeola 481 p.
Ariſtoteles 478 m. 479 m. 485 m. 487 f. 492 m. 493 p. 498 p.
Ariſtophanes 486 p.
Arces ſubterraneæ 482 m. f.
Aſcalabus, & ἀσκαλαβώτης, qui & ſtellio 493 m.
Aſcarides 499 f. 500 f.
Aſelli rimis parietum occultantur 481 f.
Aſellus piſcis æſtiuis menſibus ſe cõdit 474 m
Aſio noctuæ ſpecies 486 p.
Aſpis, & eius genera 497 m. f.
Attagenes 481 m.
Aues hyeme in cauis arboribus latẽtes 481 f.
Aues luteæ 479 m.
Aues quædam cur uerno tempore conſpiciantur implumes 482 p.
Aues nocturnæ 485 f.
Aurata æſtiuis menſibus ſe condit 494 m.

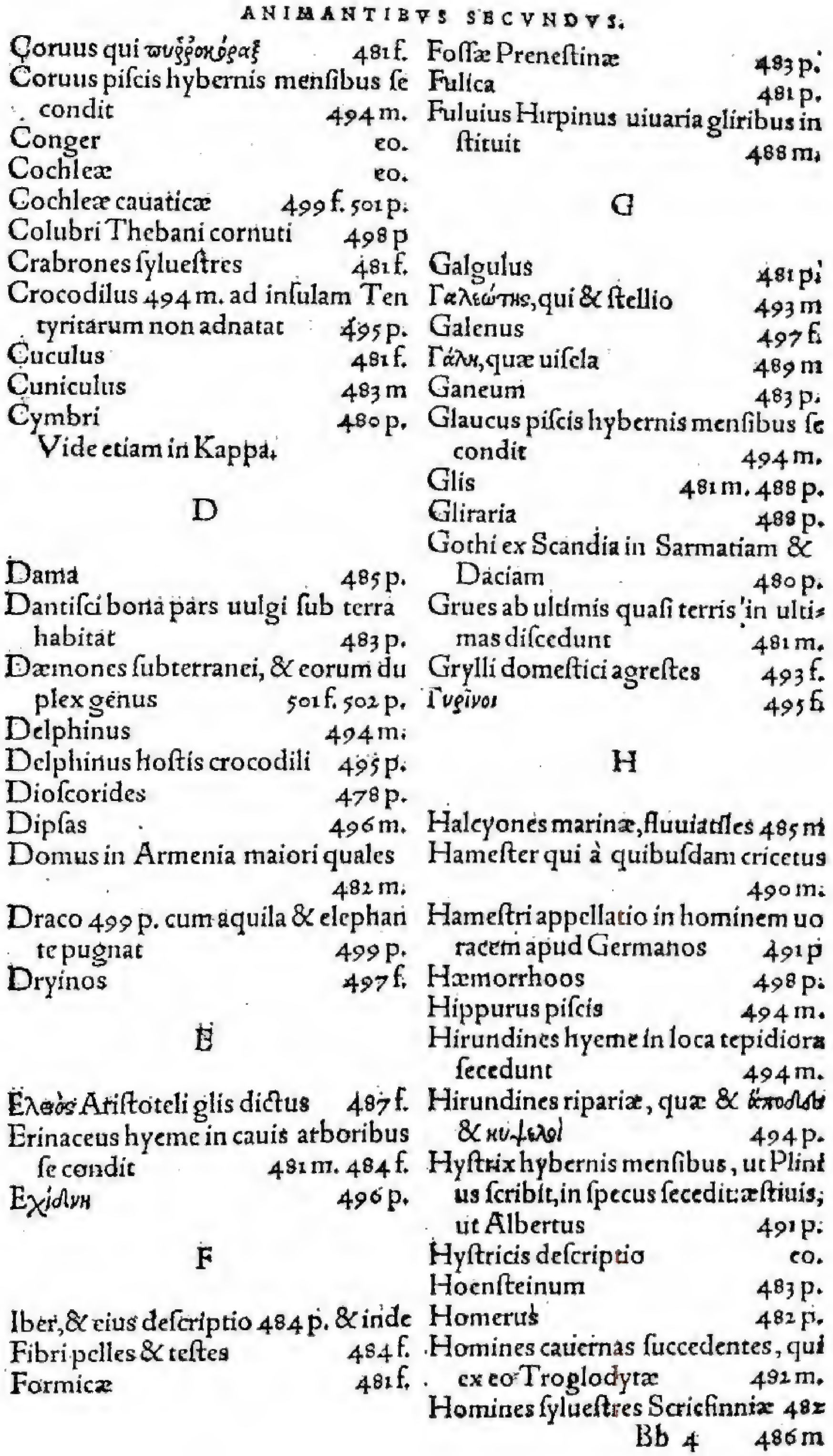
B

Baſiliſcus 498 f.
Βατραχίδες 495 f.
Blattæ parietum rimis occultantur 481 f.
Boæ ex natricum genere 497 m
Βρίξας, rana 495 m.
Bubo 485 f. 494 m.
Buccina 494 m.
Bufo 495 f.

C

Cancer fluuiatilis 496 p.
Calabricus ſerpens 497 p.
Caprea 485 p.
Caſſianus theologus 499 p
Κάστωρ 484 f.
Caſtorea eo.
Caucaſus mons 482 m
Cauſon quæ & dipſas 496 f.
Cæcula hyeme ſe condit in terra 496 f.
Cellæ ſubterraneæ 482 m.
Cenchris ſerpens 498 m.
Centipeda quæ & ſcolopẽdra 494 p
Cephi Æthiopici 480 m.
Ceraſtes 497 f.
Ceruus 485 p.
Ciconiæ 481 m.
Chamæleõ 492 m. aura alitur 493 p.
Χαμαιτυπεῖα 483 p.
Chelydros 497 f.
Cherſydros 497 p.
Cicero 499 m. 500 p.
Circe 482 m.
Cleopatra aſpidas ptyadas ſibi admouit 497 f.
Columella 496 f.
Cœnobium ſubterraneum in Sedunis 482 m.
Corpus ſubterraneum & eius diuiſio 479 p.
Coruus aquaticus 481 p.

Coruus



Coruus qui πυῤῥοκόραξ 481 f.
Coruus piſcis hybernis menſibus ſe condit 494 m.
Conger eo.
Cochleæ eo.
Cochleæ cauaticæ 499 f. 501 p.
Colubri Thebani cornuti 498 p
Crabrones ſylueſtres 481 f.
Crocodilus 494 m. ad inſulam Tentyritarum non adnatat 495 p.
Cuculus 481 f.
Cuniculus 483 m
Cymbri 480 p.
Vide etiam in Kappa.

D

Dama 485 p.
Dantiſci bona pars uulgi ſub terra habitat 483 p.
Dæmones ſubterranei, & eorum duplex genus 501 f. 502 p.
Delphinus 494 m.
Delphinus hoſtis crocodili 495 p.
Dioſcorides 478 p.
Dipſas 496 m.
Domus in Armenia maiori quales 482 m.
Draco 499 p. cum aquila & elephante pugnat 499 p.
Dryinos 497 f.

E

Ελειὸς Ariſtoteli glis dictus 487 f.
Erinaceus hyeme in cauis arboribus ſe condit 481 m. 484 f.
Εχίδνη 496 p.

F

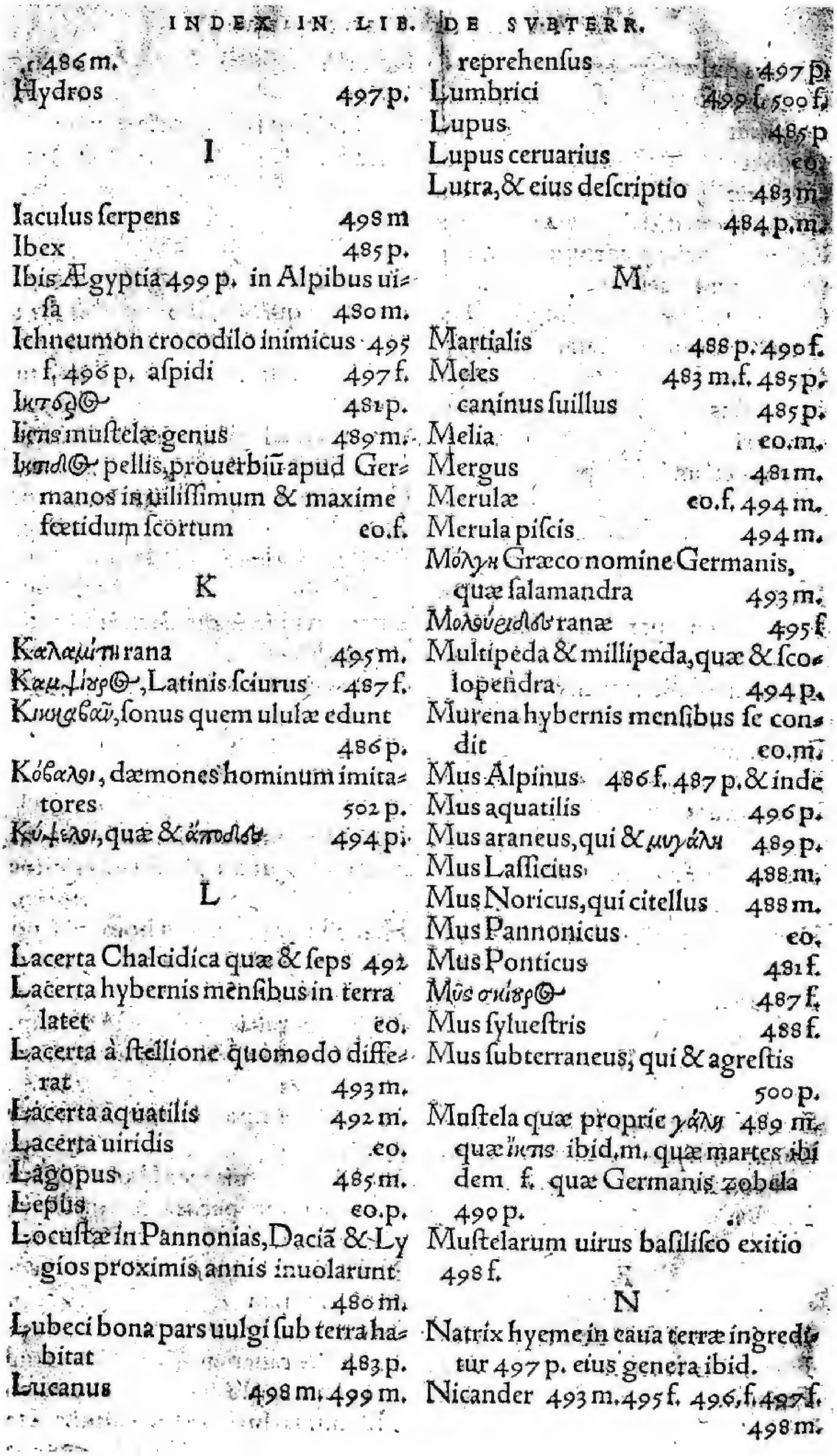
Iber, & eius deſcriptio 484 p. & inde
Fibri pelles & teſtes 484 f.
Formicæ 481 f.
Foſſæ Preneſtinæ 483 p.
Fulica 481 p.
Fuluius Hirpinus uiuaria gliribus inſtituit 488 m.

G

Galgulus 481 p.
Γαλεώτης, qui & ſtellio 493 m
Galenus 497 f.
Γάλη, quæ uiſela 489 m
Ganeum 483 p.
Glaucus piſcis hybernis menſibus ſe condit 494 m.
Glis 481 m. 488 p.
Gliraria 488 p.
Gothi ex Scandia in Sarmatiam & Daciam 480 p.
Grues ab ultimis quaſi terris in ultimas diſcedunt 481 m.
Grylli domeſtici agreſtes 493 f.
Γυρῖνοι 495 f.

H

Halcyones marinæ, fluuiatiles 485 m
Hameſter qui à quibuſdam cricetus 490 m.
Hameſtri appellatio in hominem uoracem apud Germanos 491 p
Hæmorrhoos 498 p.
Hippurus piſcis 494 m.
Hirundines hyeme in loca tepidiora ſecedunt 494 m.
Hirundines ripariæ, quæ & ἄποδες & κυψελοι 494 p.
Hyſtrix hybernis menſibus, ut Plinius ſcribit, in ſpecus ſecedit: æſtiuis, ut Albertus 491 p.
Hyſtricis deſcriptio eo.
Hoenſteinum 483 p.
Homerus 482 p.
Homines cauernas ſuccedentes, qui ex eo Troglodytæ 492 m.
Homines ſylueſtres Scricfinniæ 482 486 m



INDEX IN LIB. DE SVBTERR.

486 m.
Hydros 497 p.

I

Iaculus ſerpens 498 m
Ibex 485 p.
Ibis Ægyptia 499 p. in Alpibus uiſa 480 m.
Ichneumon crocodilo inimicus 495 f. 496 p. aſpidi 497 f.
Ἴκτερος 481 p.
Ἴκτις muſtelæ genus 489 m.
Ἰκτίδος pellis, prouerbiũ apud Germanos in uiliſſimum & maxime fœtidum ſcortum eo. f.

K

Καλαμίτης rana 495 m.
Καμψίουρος, Latinis ſciurus 487 f.
Κικκαβαῦ, ſonus quem ululæ edunt 486 p.
Κόβαλοι, dæmones hominum imitatores 502 p.
Κύψελοι, quæ & ἄποδες 494 p.

L

Lacerta Chalcidica quæ & ſeps 492
Lacerta hybernis menſibus in terra latet eo.
Lacerta à ſtellione quomodo differat 493 m.
Lacerta aquatilis 492 m.
Lacerta uiridis eo.
Lagopus 485 m.
Lepus eo. p.
Locuſtæ in Pannonias, Daciã & Lygios proximis annis inuolarunt 480 m.
Lubeci bona pars uulgi ſub terra habitat 483 p.
Lucanus 498 m. 499 m.

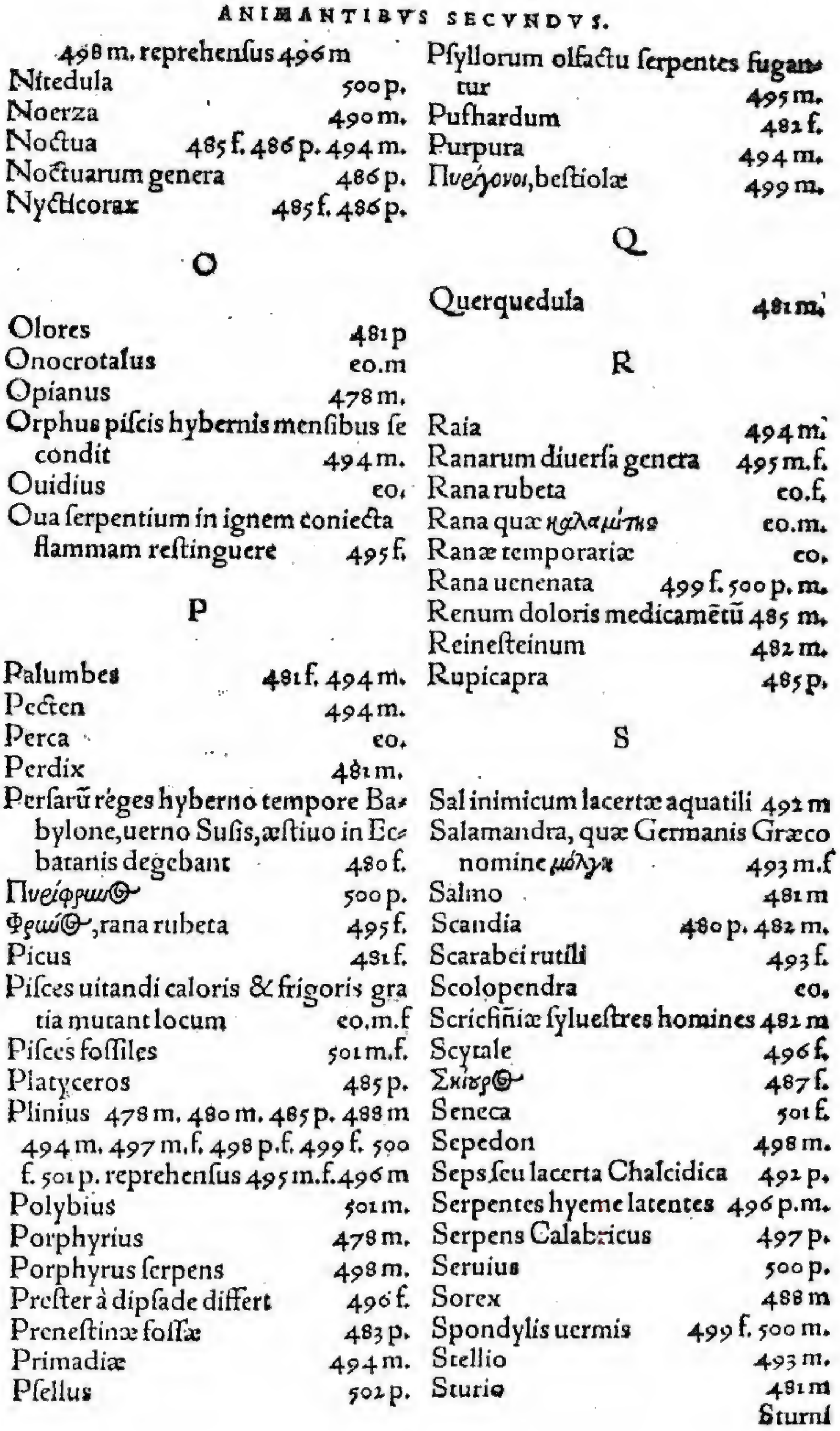
reprehenſus 497 p.
Lumbrici 499 f. 500 f.
Lupus 485 p
Lupus ceruarius eo.
Lutra, & eius deſcriptio 483 m. 484 p. m.

M

Martialis 488 p. 490 f.
Meles 483 m. f. 485 p.
caninus ſuillus 485 p.
Melia eo. m.
Mergus 481 m.
Merulæ eo. f. 494 m.
Merula piſcis 494 m.
Μόλγη Græco nomine Germanis, quæ ſalamandra 493 m.
Μολυβειδὲς ranæ 495 f.
Multipeda & millipeda, quæ & ſcolopendra 494 p.
Murena hybernis menſibus ſe condit eo. m.
Mus Alpinus 486 f. 487 p. & inde
Mus aquatilis 496 p.
Mus araneus, qui & μυγάλη 489 p.
Mus Laſſicius 488 m.
Mus Noricus, qui citellus 488 m.
Mus Pannonicus eo.
Mus Ponticus 481 f.
Μῦς σκίουρος 487 f.
Mus ſylueſtris 488 f.
Mus ſubterraneus, qui & agreſtis 500 p.
Muſtela quæ proprie γαλῆ 489 m. quæ ἴκτις ibid. m. quæ martes ibidem f. quæ Germanis zobela 490 p.
Muſtelarum uirus baſiliſco exitio 498 f.

N

Natrix hyeme in caua terræ ingreditur 497 p. eius genera ibid.
Nicander 493 m. 495 f. 496 f. 497 f. 498 m.



ANIMANTIBVS SECVNDVS.

498 m. reprehenſus 496 m
Nitedula 500 p.
Noerza 490 m.
Noctua 485 f. 486 p. 494 m.
Noctuarum genera 486 p.
Nycticorax 485 f. 486 p.

O

Olores 481 p
Onocrotalus eo. m
Opianus 478 m.
Orphus piſcis hybernis menſibus ſe condit 494 m.
Ouidius eo.
Oua ſerpentium in ignem coniecta flammam reſtinguere 495 f.

P

Palumbes 481 f. 494 m.
Pecten 494 m.
Perca eo.
Perdix 481 m.
Perſarũ reges hyberno tempore Babylone, uerno Suſis, æſtiuo in Ecbatanis degebant 480 f.
Πυρίφρυνος 500 p.
Φρύνος, rana rubeta 495 f.
Picus 481 f.
Piſces uitandi caloris & frigoris gratia mutant locum eo. m. f
Piſces foſſiles 501 m. f.
Platyceros 485 p.
Plinius 478 m. 480 m. 485 p. 488 m 494 m. 497 m. f. 498 p. f. 499 f. 500 f. 501 p. reprehenſus 495 m. f. 496 m
Polybius 501 m.
Porphyrius 478 m.
Porphyrus ſerpens 498 m.
Preſter à dipſade differt 496 f.
Preneſtinæ foſſæ 483 p.
Primadiæ 494 m.
Pſellus 502 p.
Pſyllorum olfactu ſerpentes fugantur 495 m.
Puſhardum 482 f.
Purpura 494 m.
Πυρίγονοι, beſtiolæ 499 m.

Q

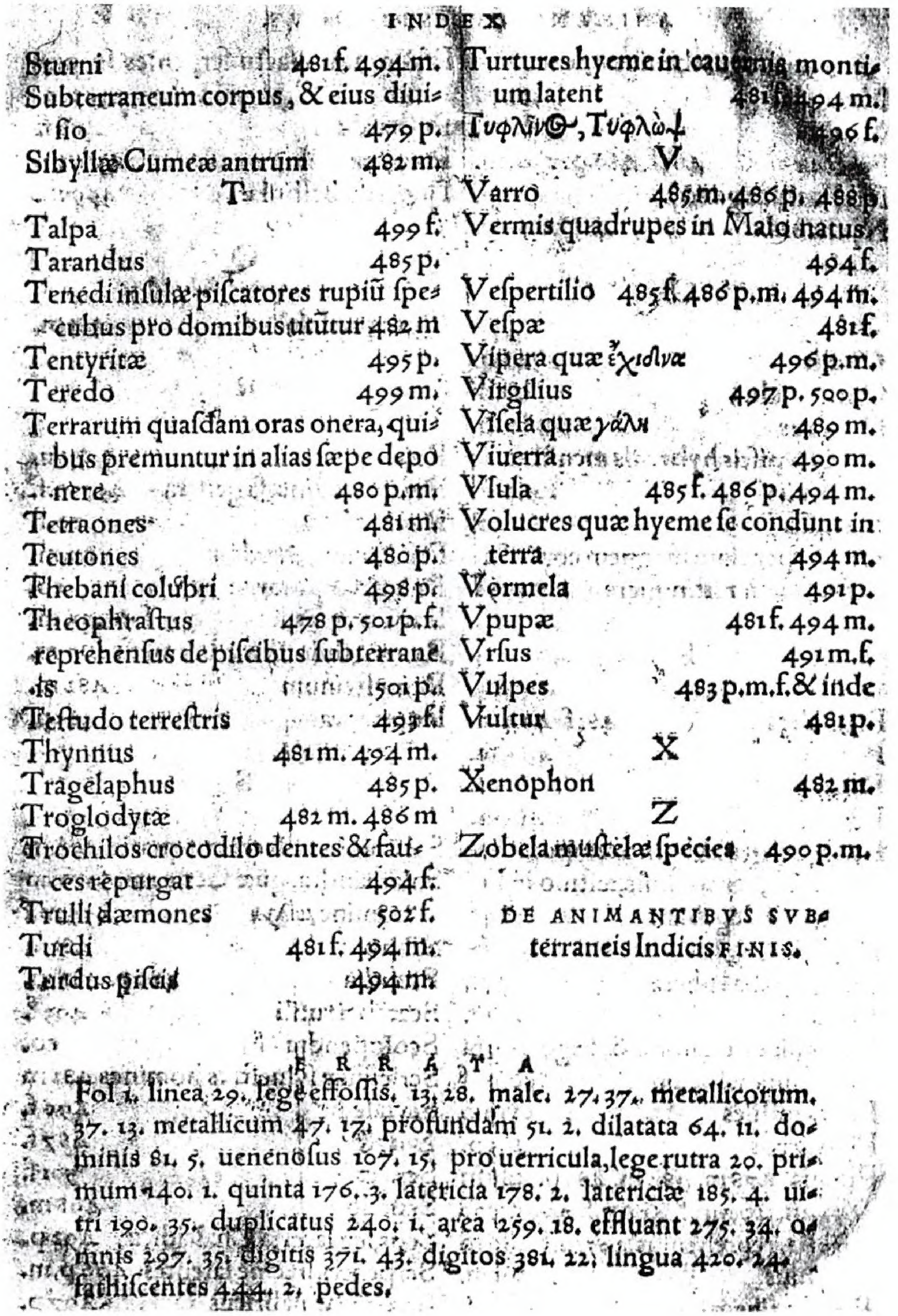
Querquedula 481 m.

R

Raia 494 m.
Ranarum diuerſa genera 495 m. f.
Rana rubeta eo. f.
Rana quæ καλαμίτης eo. m.
Ranæ temporariæ eo.
Rana uenenata 499 f. 500 p. m.
Renum doloris medicamẽtũ 485 m.
Reineſteinum 482 m.
Rupicapra 485 p.

S

Sal inimicum lacertæ aquatili 492 m
Salamandra, quæ Germanis Græco nomine μόλγη 493 m. f
Salmo 481 m
Scandia 480 p. 482 m.
Scarabei rutili 493 f.
Scolopendra eo.
Scrichñiæ ſylueſtres homines 482 m
Scytale 496 f.
Σκίουρος 487 f.
Seneca 501 f.
Sepedon 498 m.
Seps ſeu lacerta Chalcidica 492 p.
Serpentes hyeme latentes 496 p. m.
Serpens Calabricus 497 p.
Seruius 500 p.
Sorex 488 m
Spondylis uermis 499 f. 500 m.
Stellio 493 m.
Sturio 481 m
Sturni



INDEX

Sturni 481 f. 494 m.
Subterraneum corpus, & eius diuiſio 479 p.
Sibyllæ Cumeæ antrum 482 m.

T

Talpa 499 f.
Tarandus 485 p.
Tenedi inſulæ piſcatores rupiũ ſpecubus pro domibus utũtur 482 m
Tentyritæ 495 p.
Teredo 499 m.
Terrarum quaſdam oras onera, quibus premuntur in alias ſæpe deponere 480 p.m.
Tetraones 481 m.
Teutones 480 p.
Thebani colubri 498 p.
Theophraſtus 478 p. 501 p.f.
  reprehenſus de piſcibus ſubterraneis 501 p.
Teſtudo terreſtris 493 f.
Thynnus 481 m. 494 m.
Tragelaphus 485 p.
Troglodytæ 482 m. 486 m
Trochilos crocodilo dentes & fauces repurgat 494 f.
Trulli dæmones 502 f.
Turdi 481 f. 494 m.
Turdus piſcis 494 m.
Turtures hyeme in cauernis montium latent 481 f. 494 m.
Τυφλῖνος, Τυφλὼψ 496 f.

V

Varro 485 m. 486 p. 488 p.
Vermis quadrupes in Maio natus, 494 f.
Veſpertilio 485 f. 486 p.m. 494 m.
Veſpæ 481 f.
Vipera quæ ἔχιδνα 496 p.m.
Virgilius 497 p. 500 p.
Viſela quæ γάλη 489 m.
Viuerra 490 m.
Vlula 485 f. 486 p. 494 m.
Volucres quæ hyeme ſe condunt in terra 494 m.
Vormela 491 p.
Vpupæ 481 f. 494 m.
Vrſus 491 m.f.
Vulpes 483 p.m.f. & inde
Vultur 481 p.

X

Xenophon 482 m.

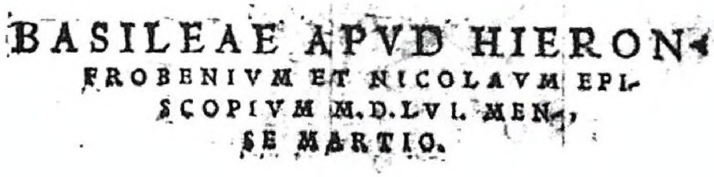
Z

Zobela muſtelæ ſpecies 490 p.m.

DE ANIMANTIBVS SVBterraneis Indicis FINIS.

ERRATA

Fol 1. linea 29. lege effoſſis. 13. 28. male. 27. 37. metallicorum. 37. 13. metallicum 47. 17. profundam 51. 2. dilatata 64. 11. dominis 81. 5. uenenoſus 107. 15. pro uerricula, lege rutra 20. primum 140. 1. quinta 176. 3. latericia 178. 2. latericiæ 185. 4. uitri 190. 35. duplicatus 240. 1. area 259. 18. effluant 275. 34. ominis 297. 35. digitis 371. 43. digitos 381. 22. lingua 420. 24. fathiſcentes 444. 2. pedes.



BASILEAE APVD HIERON-
FROBENIVM ET NICOLAVM EPI-
SCOPIVM M.D.LVI. MEN-
SE MARTIO.

CALIFORNIA ACADEMY OF SCIENCES

PROCEEDINGS SERIES

INSTRUCTIONS TO AUTHORS

Authors planning to submit papers for consideration for publication in the Academy's *Proceedings, Occasional Papers,* or *Memoir* series must follow the directions given below in preparing their submissions. Under some circumstances, authors may not be able to comply with all the computer-based requirements for submission. Should this be the case, please contact the Editor or Associate Editor for guidance on how best to present the materials.

The Scientific Publications Office of the Academy prepares all materials for publication using state-of-the-art, computer-assisted, page-description-language software. Final copy is sent to the printer for printing. The printer does not modify the files sent for printing. Therefore, it falls to the authors to check carefully page proof when it is returned for approval. Ordinarily, all communication with authors is done via email and galley and page proofs of manuscripts, including figures, are transmitted as attachments to email communications. Again, exceptions to this will be made in the event that an author is unable to communicate in this way.

Authors are expected to provide digital copies of both manuscript text files and images, as well as a paper printout of their manuscript. Please note the following:

TEXT: Text can be in Microsoft Word, as a Word document file, WordPerfect, also as a WP document file, or, best of all, as an "rtf" (rich text format) file, which can be produced by most word processors. Authors who use non-standard fonts must include file copies of those fonts so that their symbols can be reproduced accurately. However, it is strongly recommended that the type style "New Times Roman" be used throughout and that the Symbols and Bookshelf Symbol 1 and 3 fonts be used for such items as ♂, ♀, ☿, μ, etc. Note, words must not be typed in all capital latters either in the text or bibliography; small caps are acceptable.

IMAGES: Images should be in either JPG (JPEG), or TIF (TIFF) format. Resolution for grayscale images should be at least 600 ppi (1200 ppi if possible, especially for photomicrographs), and 300 ppi (600 ppi acceptable) for color. All images should be sized so that none exceeds a maximum print size of 5.5″×7.875″ (140 mm × 200 mm).

TABLES: Our processing software allows for direct importation of tables. This reduces the chances for errors being introduced during the preparation of manuscripts for publication. However, in order to use this feature, tables must be prepared in Microsoft Excel or in Microsoft Word using Word's table feature; do not prepare tables using tabs or space bars. Complex tables not prepared as described above will be returned to the author for revision.

DIGITAL FILES: IBM or MAC formatted disks will be accepted subject to the following conditions: (a) floppy disks must not exceed 1.4 mb and (b) zip disks, preferably IBM format, must not exceed 100mb. Authors are encouraged to submit their digital files on CD-ROM (CD-R formatted disks NOT CD-RW) inasmuch as these can be read by nearly all CD-ROM drives.

FILE NAMING PROTOCOLS: To facilitate the handling of digital files submitted by authors, the following file-naming conventions are to be followed: text files should bear the author's last name (in the case of multiple authors, only the first author's name) followed by a space and a date in the format mmyy (e.g., 0603 for June 2003) to yield a file name such as **Gosliner 0603.doc** or **Williams 0603.rtf.** If an author has submitted two or more manuscripts and must distinguish between them, then the naming should include an additional numeral: **Gosliner1** 0603.doc for the first manuscript, **Gosliner2** 0603.doc (or .rtf) for the second. Figures should follow similar conventions, as follows: **Gosliner F1 0603.tif, Gosliner F2 0603.tif,** for figures in the first manuscript and, if more than one manuscript, then **Gosliner1 F1 0603.tif** etc. for the figures associated with the first manuscript and **Gosliner2 F1 0603.tif** etc. for those with the second. Following these conventions will insure that figures submitted by one author are always maintained distinct from those submitted by another. Tables submitted as Excel files should follow the same naming conventions except the file type designation will be ".xls": e.g., **Gosliner T1 0603.xls.** Please note that extraneous periods are omitted in file names.

BIBLIOGRAPHY FORMAT: Three bibliographic styles are accommodated in the Academy's scientific publications, one commonly used in scientific journals publishing papers in systematic and evolutionary biology, a second used mainly in the geological literature, and lastly, the format most commonly used in the humanities by historians of science. On request, the author will be sent a style sheet that includes samples of the three formats. Authors are also encouraged to examine a copy of the latest published *Proceedings*. In all instances, however, authors should not abbreviate journal names but spell them out completely. For books, the reference must include the publisher and city of publication. It is recommended that the total number of pages in the book also be given.

SUBSCRIPTIONS

The *Proceedings* series of the California Academy of Sciences is available by exchange or subscription. For information on exchanges, please contact the Academy Librarian via regular mail addressed to the Librarian, California Academy of Sciences, 55 Music Concourse Drive, Golden Gate Park, San Francisco, CA 94118 U.S.A. or via email addressed to **lcurrie@calacademy.org.** Subscription requests, including information on rates, should be addressed to Scientific Publications, California Academy of Sciences,55 Music Concourse Drive, Golden Gate Park, San Francisco, CA 94118 U.S.A. or via email to the Editor at **scipubs@calacademy.org.**

Subscription price for 2009: $75 (US) includes mailing to U.S. and Canadian addresses and $85 to all others.

The *Occasional Papers* and *Memoirs* are not available by subscription. Each volume is priced separately. *Occasional Papers, Memoirs,* and individual issues of the *Proceedings* are available for purchase through the Academy's Office of Scientific Publications. Visit us on the web at *<http://research.calacademy.org/research/scipubs/>.*

COMMENTS

Address editorial correspondence or requests for pricing information to the Editor, Scientific Publications Office, California Academy of Sciences, 55 Music Concourse Drive, Golden Gate Park, San Francisco, CA 94118 U.S.A. or via email to the Editor, Scientific Publications, at **scipubs@calacademy.org.**

TABLE OF CONTENTS

THOMAS F. DANIEL: Synopsis of *Dicliptera* (Acanthaceae) in the Nueva Galicia Region of Western Mexico with a New Species, *D. novogaliciana* 1

THOMAS F. DANIEL AND EMILY J. LOTT: *Justicia cuixmalensis*, a New Species of Acanthaceae from West-central Mexico 19

MICHAEL S. ENGEL, ISMAEL A. HINOJOSA-DÍAZ, AND ALEXANDR P. RASNITSYN: A Honey Bee from the Miocene of Nevada and the Biogeography of *Apis* (Hymenoptera: Apidae: Apini) 23

PETER MCMILLAN AND TOMIO IWAMOTO: Two New Species of *Coelorinchus* (Teleostei, Gadiformes, Macrouridae) from the Tasman Sea 39

REBECCA C. WENK AND THOMAS F. DANIEL: Molecular Phylogeny of Nelsonioideae (Acanthaceae) and Phylogeography of *Elytraria* 53

DARIN S. PENNEYS AND LOU JOST: *Blakea attenboroughii* (Melastomataceae: Blakeeae): A New Species from Ecuador 69

DAVID H. KAVANAUGH AND SEAN D. SCHOVILLE: A New and Endemic Species of *Nebria* Latreille (Insecta: Coleoptera: Carabidae: Nebriini), Threatened by Climate Change in the Trinity Alps of Northern California 73

PAUL H. ARNAUD, JR. AND DAVID H. KAVANAUGH: In Memoriam: Hugh Bosdin Leech (1910-1990) 85

MICHELE L. ALDRICH, ALAN E. LEVITON, AND LINDSAY L. SEARS: Georgius Agricola, *De Animantibus Subterraneis*, 1549 and 1556: A Translation of a Renaissance Essay in Zoology and Natural History 89